July 2009

Economic Impacts of Revised MACT Standards for Hospital/Medical/Infectious Waste Incinerators

Final Report

Prepared for

Tom Walton
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
(MD-C439-02)
Research Triangle Park, NC 27711

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1
BACKGROUND

Following legislative and administrative requirements, the U.S. Environmental Protection Agency (EPA) conducts economic analysis of its regulatory actions. The Air Benefit and Cost Group (ABCG) is responsible for conducting such economic analyses in support of residual risk and national emission standards for hazardous air pollutants (NESHAP), new source performance standards (NSPS), and national ambient air quality standards (NAAQS) for criteria pollutants. Recently, a revised rule for hospital/medical/infectious waste incinerators (HMIWI) has been considered, resulting in this economic impact analysis (EIA) for the industry.

The evolution of HMIWI regulations has been ongoing for 2 decades. In 1988, Congress amended the Resource Conservation and Recovery Act (RCRA) through the Medical Waste Tracking Act (MWTA) with RCRA subtitle J (EPA, 2008). This subtitle, which established a two-year program for tracking medical wastes in several states, defined medical waste as "any solid waste which is generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in production or testing of biologicals" (MWTA). Today, medical wastes are managed under RCRA Subtitle C if they are RCRA listed or characteristic hazardous wastes. Otherwise, they are managed as non-hazardous solid waste.

In 1997, EPA followed these regulations with NSPS and emissions guidelines established under sections 111 and 129 of the Clean Air Act (CAA). The NSPS and emissions guidelines were designed to reduce air emissions from new and existing HMIWI. A HMIWI is defined as any device used to burn hospital waste or medical/infectious waste. Hospital waste is defined as "discards generated at a hospital," and medical/infectious waste is defined similar to RCRA subtitle J. In 1999, the HMIWI regulations were remanded by the U.S. Court of Appeals for the D.C. Circuit. The fundamental issue leading to the remand was the approach and methodology used by EPA to develop the HMIWI regulations. Although the Court remanded the regulations to EPA for further explanation, it did not vacate them, so the NSPS and emissions guidelines remain in effect and were fully implemented by 2002. In 2007, EPA proposed a response to the questions raised in the Court's remand, as well as a response to the CAA section 129(a)(5) requirement to review the NSPS and emissions guidelines every 5 years (EPA 2007). However, recent Court decisions that impact that proposal, as well as issues raised in the public comments regarding that proposal, necessitated a re-proposal of the response to the questions raised in the Court's remand. After receiving comments on the re-proposed rule, EPA has developed final standards for existing and new HMIWI. This rule also satisfies the CAA section 129(a)(5) requirement to conduct a review of the standard every 5 years. This analysis examines the economic impacts of the final rule.

This EIA contains four other sections. The second section of the EIA is a profile of the HMIWI industry. It provides the reader with a basic understanding of the structure of the HMIWI market, as well as the characteristics of HMIWI operators and demanders. Section 3 describes the estimated costs that would be incurred by the HMIWI industry with the promulgation of the revised regulations for the industry. Section 4 analyzes the impacts of these costs on the industry. Section 5 provides conclusions.

SECTION 2
INDUSTRY PROFILE

2.1 Introduction

HMIWI provide waste management services to medical, pharmaceutical, veterinary, and research facilities that generate solid waste through their activities. Some HMIWI are commercial enterprises that offer these services to a variety of generators. Other HMIWI are owned and operated by the generators themselves. This industry profile provides an overview of the generation and management of hospital/medical/infectious waste, and characterizes the role of HMIWI as a part of this waste management. In addition, the profile provides a detailed examination of currently operating HMIWI.

In brief, the medical waste sector of the waste management and remediation industry has seen vast amounts of growth in recent years, and all trends point toward an increase in this growth at an average annual growth rate of 5.7%. Receipts received by the Solid Waste Combustors and Incinerators sector (North American Industry Classification System [NAICS] 562213) grew by 10.75% between 1997 and 2002. However, since 1994 the number of HMIWI has declined precipitously: initially, EPA identified thousands of HMIWI; in 2008, there are only 57.

This profile is organized as follows: Section 2.2 describes the demand side of the industry, including characterizing the waste generated by medical, veterinary, and research facilities. Section 2.3 describes the supply of waste management services, including HMIWI. The last two sections discuss industry organization and market trends/information.

2.2 The Demand Side of Medical Waste Management Services

Much of this industry profile discusses the relationship between general medical waste and incinerated waste. This section of the profile provides information related to the total volume of waste output from medical facilities and the resulting demand this output creates for treating medical waste. Subsection 2.2.1 discusses the different types of medical waste and their volumes. Section 2.2.2 explains the relationship between the different types of medical waste and treatment by incineration.

2.2.1 General Medical Waste

The demand for medical waste management comes from hospitals, pharmaceutical and other research facilities, laboratories, clinic/outpatient care, physicians' offices, dentists' offices, veterinarians, long-term health care facilities, free-standing blood banks, and funeral homes. Since EPA's 1997 NSPS and emissions guidelines, the number of HMIWI has decreased drastically from over 2,300 in 1996 (EPA, 1996) to 57 when this report was written. In 2008, 71% of medical waste is generated in hospitals. In 1994, infectious waste accounted for 15% of total waste generated, as shown in Table 2-1 (EPA, 1994).

Table 2-1. Estimated U.S. Medical Facilities and Annual Waste Generated (1994 est.)

Generator Category	Number of Facilities	Annual Infectious Waste Generated (tons)	Annual Total Waste Generated (tons)
Hospitals	7,000	360,000	2,400,000
Laboratories			
Medical	4,900	17,600	117,500
Research	2,300	8,300	55,500
Subtotal	7,200	25,900	173,000
Clinics (outpatient)	41,300	26,300	175,000
Physicians (outpatient) offices	180,000	35,200	235,000
Dentist's offices	98,000	8,700	58,000
Veterinarians	38,000	4,600	31,000
Long-term care facilities			
Nursing homes	18,800	29,700	198,000
Residential care	23,900	1,400	9,000
Subtotal	42,700	31,100	207,000
Free-standing blood banks	900	4,900	33,000
Funeral homes	21,000	900	6,000
Health units in industry	2,217,000	1,400	9,000
Fire and rescue	7,200	1,600	11,000
Corrections	4,300	3,300	22,000
Police	13,100	<100	<1,000
Total	**682,400**	**504,000**	**3,361,100**

Source: U.S. Environmental Protection Agency (EPA). July 1994. Medical Waste Incinerators—Background information for Proposed Guidelines: Industry Profile for New and Existing Facilities. EPA-453/R-94-042a. Research Triangle Park, NC: EPA.

Hospitals generate different types of medical wastes, and not all of these wastes are infectious to humans. Guidelines for infectious waste differ across regulatory agencies; EPA and the Centers for Disease Control and Prevention (CDC) both have different guidelines for defining infectious waste. Data from a hospital survey cited by EPA (1994) show that hospitals report a median of 15% of their waste as infectious. In the study, the median share of infectious waste according to CDC guidelines was 5.5%, and the median according to EPA guidelines was 13%. A subset of hospitals instituted a set of CDC "universal precaution" standards that are used as informal indicators of infectious waste, but are not regulated as such. These hospitals reported a median of 23% infectious waste out of their total output of waste (EPA, 1994). Table 2-2 provides a list of the types of medical waste and their characteristics.

Table 2-2. Regulated Medical Wastes

Type of Waste	Characteristics
Cultures and Stocks	Cultures and stocks of infectious agents and associated biologicals, including cultures from medical and pathological laboratories; cultures from medical and pathological laboratories; cultures and stocks of infectious agents from research and industrial laboratories; wastes from the production of biologicals; discarded live and attenuated vaccines; and culture dishes and devices used to transfer, inoculate, and mix cultures.
Pathological and chemo wastes	Human pathological wastes, including tissues, organs, and body parts and body fluids that are removed during surgery or autopsy or other medical procedures and specimens of body fluids and their containers.
Human blood and blood products	(a) Liquid waste human blood; (b) products of blood; (c) items saturated and/or dripping with human blood; or (d) items that were saturated and/or dripping with human blood that are now caked with dried human blood, including serum, plasma, and other blood components and their containers, which were used or intended for use in patient care, testing and laboratory analysis, or the development of pharmaceuticals. Intravenous bags are also included in this category.
Sharps	Sharps that have been used in animal or human patient care or treatment or in medical, research, or industrial laboratories, including hypodermic needles, syringes (with or without the attached needle), Pasteur pipettes, scalpel blades, blood vials, needles with attached tubing, and culture dishes (regardless of presence of infectious agents). Also included are other types of broken or unbroken glassware that were in contact with infectious agents, such as used slides and cover slips.
Animal wastes	Contaminated animal carcasses, body parts, and bedding of animals that were known to have been exposed to infectious agents during research (including research in veterinary hospitals), production of biologicals, or testing of pharmaceuticals.
Isolation wastes	Biological waste and discarded materials contaminated with blood, excretion, exudates, or secretions from humans who are isolated to protect others from certain highly communicable diseases or from isolated animals known to be infected with highly communicable diseases.

Source: U.S. Environmental Protection Agency (EPA). July 1994. *Background Information for Proposed Standards and Guidelines—Industry Profile Report*. EPA-453/R-94-042a. Research Triangle Park, NC: EPA.

2.2.2 *Waste Sent to Incinerators*

Among these waste categories, between 12% and 13% of the waste generated by hospitals is classified as general infectious waste, and between 2% and 3% is classified as pathological and chemo waste (and human blood products) (see Figure 2-1). Thus, 14% to 16% of the waste generated must be treated. According to John Leigh, manager of waste and recycling programs at Dartmouth Hitchcock Medical Center, general infectious waste can be treated by autoclaving and does not necessarily need to be incinerated. However, waste with higher liquid content, such as pathological and chemo waste, and human blood and blood products, cannot be autoclaved (Leigh, 2008). Thus, only 2% to 3% of total hospital waste has no treatment alternative to incineration. This does not mean that only 2% to 3% of total hospital waste will be incinerated. Often, inadequate waste segregation due to poor waste management techniques and lack of staff training will result in more waste sent to incinerators than necessary (Krisiunas, 2008).

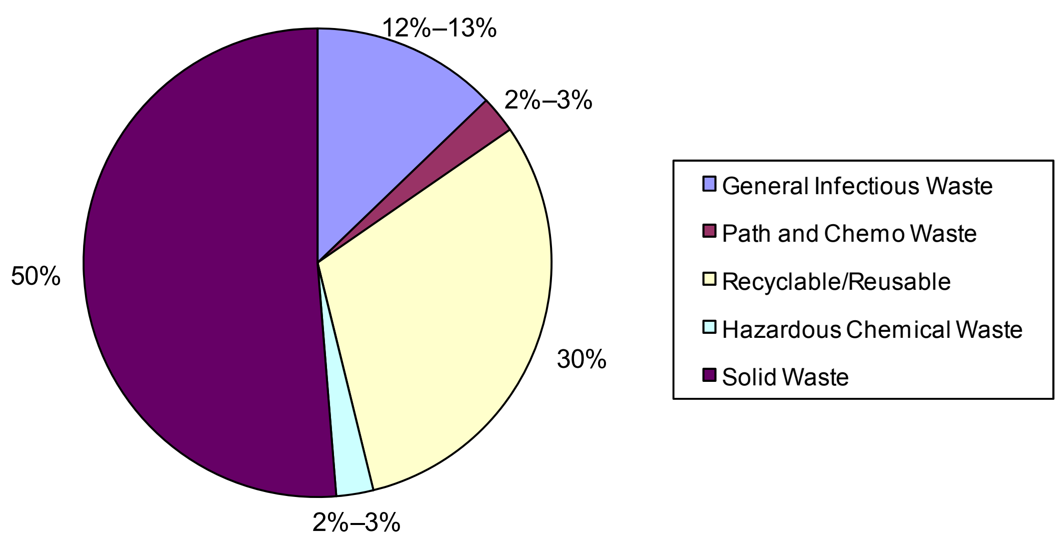


Figure 2-1. Types and Percentages of Hospital Waste

Source: American Society for Healthcare Environmental Services (ASHES). 1993. An Ounce of Prevention: Waste Reduction Strategies for Health Care Facilities, ASHES, AHA Catalog No. 057007.

Table 2-3 shows data from Dartmouth-Hitchcock Medical Center (DHMC), which provides an example of the relationship between total hospital waste generated and total waste incinerated. DHMC has an on-site autoclaving machine, which treats 75% of their regulated medical waste. Sharps require a more elaborate disinfection process that is not available on site, so they are treated at a more advanced autoclave in a commercially operated facility. Meanwhile, “Red Bag” (pathological and chemo) waste is incinerated by a commercially operated incinerator

Table 2-3. Distribution of Medical Waste Treatment Methods at Dartmouth-Hitchcock Medical Center 2007

	Quantity		Cost		
Method of Waste Treatment	**Pounds**	**Percent**	**Cost**	**Percent**	**$ Per Pound**
Autoclaved on site	471,825	75.3%	$19,192	13.4%	$0.04
Sharps	105,359	16.8%	$100,366	70.0%	$0.95
"Red bag" incinerated waste	48,998	7.8%	$23,803	16.6%	$0.49
Total	**626,182**		**$143,361**		

Source: Leigh, J. Manager, Waste & Recycling Programs DHMC. 2008. Personal communication with Vesall Nourani, RTI.

(Leigh, 2008). Incinerated waste accounts for 7.8% of total medical waste and 16.6% of the total cost.

It must be noted, however, that DHMC provides an example of a captive, in-hospital, incinerator unit, which is able to segregate waste to minimize the quantity of waste incinerated. This is not the case with commercial entities, which usually accept waste that is not separated based on waste category. As a result, commercial entities incinerate more waste than is optimal, and incur higher incineration costs. This relationship will be discussed in more detail in Section 2.5 of this report.

2.3 The Supply of Medical Waste Management Services

Infectious components in medical waste must be treated before the waste can be disposed of in landfills. In the early 1990s, the easiest and most efficient method of treatment was incineration; however, since the 1997 NSPS and emissions guidelines, over 2,000 incinerators have shut down. Alternatives to incineration are introduced in Section 2.3.1. The process and costs associated with treating medical waste by incineration are discussed in Sections 2.3.2 and 2.3.3.

2.3.1 Treating and Disposing of Medical Waste

The following section examines the process of treating and disposing of medical and infectious wastes. Treatment processes discussed include incineration, steam sterilization, thermal inactivation, chemical disinfection, gas sterilization, irradiation sterilization, ultraviolet radiation, and microwave sterilization. Disposal of waste is determined by the type of treatment and waste.

2.3.1.1 Treatment

The most common methods for treating medical waste today are incineration, autoclaving, and heat-related sterilization (Leigh, 2008). More advanced treatment methods are used to treat sharps. The following options for medical waste treatment are presented in EPA's (1994) initial industry profile of the medical waste industry.

Incineration (Meaney and Cheremisinoff, 1989). Medical waste is burned in incineration units under controlled conditions to yield ash and combustion gases. Modern incineration units usually consist of two chambers. The waste is combusted in the primary chamber, usually at temperatures between 1,200°F and 1,400°F. Airborne contaminants, such as volatile organics, that are released from the primary chamber are combusted in the secondary chamber.

Steam Sterilization (Meaney and Cheremisinoff, 1989; EPA, 1989). Steam sterilization, or autoclaving, is the process of exposing medical waste to saturated steam under pressure for a specified period of time to render the waste noninfectious. The effectiveness of autoclaving can be influenced by the duration of the cycle, the amount of pressure, the temperature, the characteristics of the waste stream, and the design of the equipment.

Thermal Inactivation (Meaney and Cheremisinoff, 1989). Thermal inactivation is similar to steam sterilization but uses dry heat rather than steam. Thermal inactivation may be used to treat both solid and liquid wastes. Solid wastes are treated in an oven, while liquid wastes are treated in a heat exchanger apparatus. Thermal inactivation is not as efficient as steam sterilization and must be monitored carefully so that wastes are exposed to the proper temperatures for the specified duration. This process is not practical for large-scale waste treatment.

Chemical Disinfection (Meaney and Cheremisinoff, 1989). Chemical disinfection kills infectious organisms by exposing them to chemicals that are strong oxidizing agents such as hydrogen peroxide or chlorine bleach. This method of treatment is generally used on the surfaces of medical equipment, but has been applied to large-scale medical waste disinfection. Chemical disinfection is generally combined with grinding or shredding prior to, or during, the disinfection process to increase the efficiency of the process and to render the waste unrecognizable.

Gas Sterilization (Meaney and Cheremisinoff, 1989). Gas sterilization involves exposing medical waste to vaporized chemicals that cause oxidation reaction damage to cellular structures. The chemical most often used is ethylene oxide. Unfortunately, ethylene oxide is a suspected human carcinogen and, thus, must be handled and used with extreme caution. Typically, reusable medical equipment is placed in a closed vacuum vessel, ranging in size from a few cubic feet to several thousand cubic feet and exposed to the sterilant gas. Although it is possible to apply this method of treatment to medical waste, the hazards associated with the chemicals preclude the widespread use of gas sterilization.

Irradiation Sterilization (Meaney and Cheremisinoff, 1989; EPA, 1989). Irradiation is currently used to sterilize medical supplies, food, and consumer products and is a technique that may be applicable to medical waste. Irradiation of medical waste with ionizing or ultraviolet radiation kills infectious agents and destroys the ability of bacteria to replicate.

The most common source of ionizing radiation is from Cobalt-60, which produces gamma radiation. Gamma radiation can penetrate up to several meters of waste and requires minimal amounts of electricity. The exposure time that is required to treat the waste varies as the radiation source decays. One commercial facility formerly used gamma irradiation for medical waste treatment. This facility, however, has switched to radio frequency irradiation treatment.

Ultraviolet Radiation (Meaney and Cheremisinoff, 1989; EPA, 1989). Ultraviolet radiation does not penetrate the waste as deeply as gamma radiation but has been used successfully in treating wastewaters. The water is exposed to ultraviolet light at a wavelength of approximately 245 nanometers. This wavelength is very close to the optimum germicidal wavelength that renders the wastewater free of infectious organisms.

Microwave Sterilization (EPA, 1989). Microwaves have been used to treat medical waste. Before being treated with the microwaves, the waste is shredded so that the waste is more efficiently exposed to the microwaves. The shredded waste is sprayed with water and treated with microwaves to a temperature of 200°F.

2.3.1.2 Disposal

Medical waste is historically disposed of in a landfill or a sanitary sewer. Solid wastes are usually landfilled, while liquid wastes are disposed of in a sewer. However, there are regulations and requirements for medical waste disposal that vary from state to state and play a significant role in how waste generators make decisions about their method of disposal. For example, there are 19 states that both require incineration of certain pathological wastes and prohibit landfilling and/or autoclaving of such wastes (MWI & IWSA, 2009). This increases the transportation cost of waste for those generators in states with such regulations.

Incinerated medical waste generally may be landfilled the same as any other solid waste, although in some cases high concentrations of toxic metals have made disposal as a hazardous waste necessary. Sanitary sewer disposal of treated or untreated liquid medical waste is minimally regulated in comparison to solid medical waste disposal. Many states do not require any treatment of liquids before they are disposed of in the sewer. Specific types of liquid wastes are sometimes required to be treated before disposal, but, in most cases, regulation of sewer disposal is left to local authorities. Often, all that is required for sewer disposal is written permission from the local sewer authority.

A benefit of incineration, relative to other treatment types, is that it greatly reduces the volume of hospital/medical/infectious waste that must be landfilled. Incineration of waste achieves a 90% volume reduction of the original waste (Mayo Clinic, 2009). Autoclaved waste successfully disinfects medical waste; however, it does not reduce the volume of waste sent to landfills.

2.3.2 Details of Incineration

According to Lee and Huffman (1996), there are three distinct types of medical waste incinerators: starved air incinerators, excess air incinerators, and rotary kilns (see Figure 2-2). Starved air incinerators and excess air incinerators fall under the modular incinerator category, while rotary kilns fall under their own category.

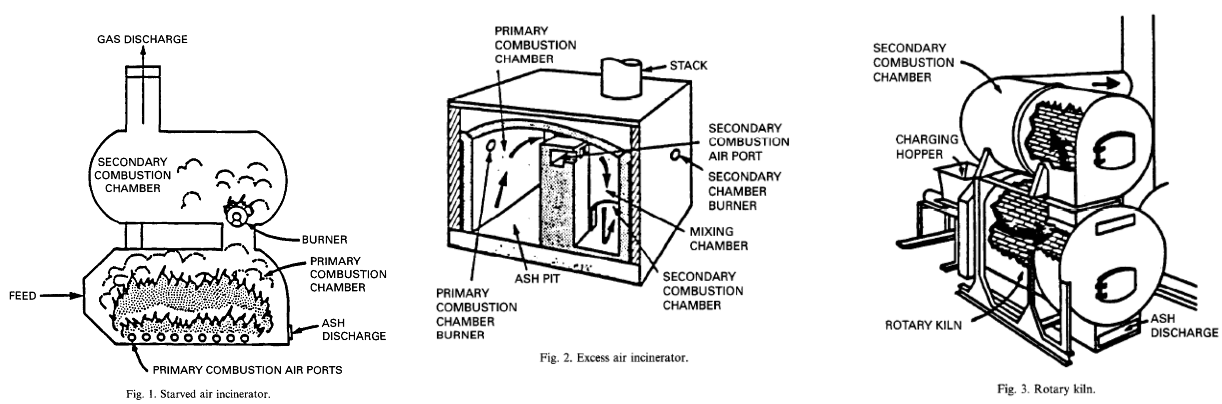


Figure 2-2. Types of Medical Waste Incinerators

All incinerators have two combustion chambers with an ash and gas discharge. The waste is generally inserted into the primary combustion chamber first. The secondary combustion chamber is used to burn out the off-gas. The resulting gas is discharged through a stack and usually consists of particulates, acid gases, nitrogen oxides (NO_x), carbon monoxide (CO), and carbon dioxide (CO_2). The acid gases are treated with air pollution control equipment (APCE) to reduce the effects of the emissions. This APCE equipment includes (Lee and Huffman, 1996) the following:

- Dry scrubber—a device that uses absorption and adsorption for removing acid gases, primarily hydrogen chloride (HCl), sulfur dioxide (SO_2), and hydrogen fluoride.
- Wet scrubber—a device that uses a liquid to clean a gas stream, including particulates (particulate matter [PM] and metals), and acid gases (HCl and SO_2).
- Baghouse (bag filter or fabric filter)—a device that removes solid particulate matter from the flue gas stream by filtering the flue gas through fabric bags, usually made of cloth or glass fibers.
- Electrostatic precipitator (ESP)—a device that electrically charges particles that are then attracted to an oppositely charged collection surface, which subsequently dislodges the particles.

The variance in the incinerator models comes from the waste's contact with air necessary for combustion. Starved air incinerators generally require less air than excess air incinerators to maintain enough heat for combustion. As a result, starved air incinerators emit less PM into the atmosphere. Rotary kilns emit the highest amount of PM because of the turbulence caused by rotation of the primary combustion chamber (Lee and Huffman, 1996).

2.3.3 Cost of Incineration

The cost for operating solid waste combustors and incinerators fluctuated a great deal between 2004 and 2006 (see Table 2-4). Expenses increased by 18.4% between 2004 and 2005, only to see a decrease of 14% in the following year. Expenses associated with NAICS 562213 represent 1.4% of the expenses associated with the entire waste management sector (NAICS 56). Table 2-4 does not represent the entire expenses associated with incinerator use, since many incinerators are located in hospitals and other facilities with different NAICS codes. We explain this in more detail in Section 2.4 of this report.

Table 2-4. Total Expenses for Solid Waste Combustors and Incinerators: 2004 through 2006 (2007$)

				Percentage Change	
	2006	**2005**	**2004**	**2006/2005**	**2005/2004**
Solid waste combustors and incinerators (NAICS 562213)	$880	$1,026	$867	−14.3%	18.4%

Source: U.S. Census Bureau. 2006 Service Annual Survey. NAICS 62. <http://www.census.gov/svsd/www/services/sas/sas_data/sas56.htm>. Washington, DC: U.S. Census Bureau.

2.4 Industry Organization

This section of the report describes the overall organization of the HMIWI industry. It lists existing incinerators of medical waste and also considers the presence of small and large incinerator owners/operators in the analysis. The HMIWI industry is subdivided into captive/on-site suppliers of HMIWI services, and commercial HMIWI. Although this section will discuss both types of HMIWI currently operating, only commercial HMIWI are actually active in the waste management industry; owners/operators of captive/on-site HMIWI are part of other industries that generate the hospital/medical/infectious waste.

The commercial HMIWI industry consists of 5 parent companies/owner entities operating 14 commercial HMIWI. According to a report by Health Care Without Harm (2002), one company, Stericycle, has a large stake in the organization of the medical waste industry. The report states, "Stericycle's contracts occupy 22% of the $1.5 billion medical waste disposal market. The company is 11 times the size of its nearest competitor, Med/Waste Inc., which has roughly a 2% market share. Another 22% of the market is served by smaller hauling companies, and 35% to 37% of hospital waste is disposed of in onsite facilities." Stericycle's incinerator use makes up 26% of the total incinerator operating hours in the country. In 2002 to 2003, Stericycle incinerated 31% of the waste that was incinerated.

2.4.1 Incineration Facilities

The United States has 57 HMIWI incinerators in use; 14 are commercially operated, 31 are located in hospitals, and the rest are located in other facilities (see Tables 2-5 and 2-6). Stericycle's eight incinerators take up 31% of the total waste throughput (tons) in the country. All commercial incinerators combined make up 72% of total incinerator throughput. Some hospitals share common waste treatment devices; however, most choose to hire commercially operated treatment providers because stringent regulations on waste transportation prevent hospitals from transporting their waste (Krisiunas, 2008).

Table 2-5 presents the list of existing HMIWI in the United States. Of the 57 incinerators, most are captive, providing services only to the hospital or other generating facility at which they are located. Fourteen of the HMIWI facilities are commercial.

Table 2-6 summarizes the industry by type of owning facility. The majority of HMIWI are co-located at hospitals that generate the waste they treat. However, as discussed above, the majority of the waste throughput is managed at commercial HMIWI.

Table 2-5. Hospital/Medical/Infectious Waste Incinerator Inventory

Facility Name	City	State	NAICS Primary	Site Description	HMIWI Through-put Size Category	New/ Existing	Commercial
Bayfront Medical Center	St. Petersburg	FL	622110	General Medical and Surgical Hospital	L	E	No
Bethesda Memorial Hospital	Boynton Beach	FL	622110	General Medical and Surgical Hospital	L	E	No
BMWNC, Inc.	Matthews	NC	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Boca Raton Community Hospital	Boca Raton	FL	622110	General Medical and Surgical Hospital	L	E	No
Bristol-Myers Squibb Co.	Wallingford	CT	325412	Pharmaceutical Manufacturing Facility	L	E	No
Centers for Disease Control and Prevention, Building 18	Atlanta	GA	923120	Public Health Facility	S	N	No
Charleston Area Medical Center, General Hospital	Charleston	WV	622110	General Medical and Surgical Hospital	L	E	No
Curtis Bay Energy	Baltimore	MD	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Curtis Bay Energy	Baltimore	MD	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Department of Veterans Affairs Medical Center	Miami	FL	622110	General Medical and Surgical Hospital	L	E	No
East Carolina University, Health Sciences Campus, HSC Utility Plant	Greenville	NC	611310	University	L	N	No
Fairfield Medical Center	Lancaster	OH	622110	General Medical and Surgical Hospital	S	E	No
Fort Detrick	Fort Detrick	MD	928110	National Security Facility	L	E	No
Fort Detrick	Fort Detrick	MD	928110	National Security Facility	L	E	No
Franklin Square Hospital Center	Baltimore	MD	622110	General Medical and Surgical Hospital	M	E	No
Good Samaritan Hospital	Vincennes	IN	622110	General Medical and Surgical Hospital	M	E	No
Hamot Medical Center	Erie	PA	622110	General Medical and Surgical Hospital	L	E	No
Healthcare Environmental Services Inc.	Fargo	ND	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Holy Cross Hospital	Fort Lauderdale	FL	622110	General Medical and Surgical Hospital	L	E	No
Holy Spirit Hospital	Camp Hill	PA	622110	General Medical and Surgical Hospital	M	E	No
Johns Hopkins Medical Institute, Department of Health Safety and Environment	Baltimore	MD	611310	University	M	E	No

(continued)

Table 2-5. Hospital/Medical/Infectious Waste Incinerator Inventory (continued)

Facility Name	City	State	NAICS Primary	Site Description	HMIWI Through-put Size Category	New/ Existing	Commercial
Kona Community Hospital	Kealakekua	HI	622110	General Medical and Surgical Hospital	SR	E	No
Lakeland Regional Medical Center	Lakeland	FL	622110	General Medical and Surgical Hospital	L	E	No
Loyola University Medical Center	Maywood	IL	622110	General Medical and Surgical Hospital	L	E	No
Malcolm Randall Veterans Affairs Medical Center	Gainesville	FL	622110	General Medical and Surgical Hospital	M	E	No
Mayo Clinic, Waste Management Facility	Rochester	MN	622110	General Medical and Surgical Hospital	L	E	No
Medcentral Health System, Mansfield Hospital	Mansfield	OH	622110	General Medical and Surgical Hospital	L	E	No
Medina General Hospital	Medina	OH	622110	General Medical and Surgical Hospital	M	E	No
Memorial Regional Hospital	Hollywood	FL	622110	General Medical and Surgical Hospital	L	E	No
Merck & Company, Inc.	Rahway	NJ	325411	Medicinal Chemical Manufacturing Facility	L	E	No
Merck & Company, Inc.	West Point (Upper Gwynedd Township)	PA	325412	Pharmaceutical Manufacturing Facility	L	E	No
Merck & Company, Inc.	West Point (Upper Gwynedd Township)	PA	325412	Pharmaceutical Manufacturing Facility	L	E	No
Parkview Hospital	Fort Wayne	IN	622110	General Medical and Surgical Hospital	L	E	No
Pennsylvania State University, Animal Diagnostic Lab Incinerator	State College	PA	611310	University	M	E	No
Riddle Memorial Hospital	Media	PA	622110	General Medical and Surgical Hospital	M	E	No
Rocky Mountain Laboratories, National Institute of Allergy and Infectious Diseases	Hamilton	MT	541710	Biomedical Research Facility	M	E	No
South Bend Medical Foundation	South Bend	IN	622110	General Medical and Surgical Hospital	M	E	No
St. Joseph's Hospital	Tampa	FL	622110	General Medical and Surgical Hospital	L	E	No
St. Joseph's Hospital	Marshfield	WI	622110	General Medical and Surgical Hospital	M	E	No

(continued)

Table 2-5. Hospital/Medical/Infectious Waste Incinerator Inventory (continued)

Facility Name	City	State	NAICS Primary	Site Description	HMIWI Through-put Size Category	New/ Existing	Commercial
St. Jude Children's Research Hospital	Memphis	TN	622310	Children's Medical and Surgical Hospital	M	E	No
Stericycle, Inc.	Apopka	FL	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Stericycle, Inc.	Haw River	NC	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Stericycle, Inc.	Haw River	NC	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Stericycle, Inc.	Clinton	IL	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Stericycle, Inc.	Clinton	IL	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Stericycle, Inc.	Warren	OH	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Stericycle, Inc.	Kansas City	KS	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Stericycle, Inc.	North Salt Lake	UT	562213	Hospital/Medical/Infectious Waste Incineration Facility	L	E	Yes
Thomas Memorial Hospital	South Charleston	WV	622110	General Medical and Surgical Hospital	M	E	No
University of Maryland at Baltimore, Environmental Health and Safety Facility	Baltimore	MD	611310	University	M	E	No
University of Texas Medical Branch	Galveston	TX	622110	General Medical and Surgical Hospital	L	E	No
Washington County Hospital	Hagerstown	MD	622110	General Medical and Surgical Hospital	M	E	No
Waste Management Resource Recovery and Recycling Center	Anahuac	TX	562213/ 924110	Hospital/Medical/Infectious Waste Incineration Facility	L	N	Yes
Waste Management Resource Recovery and Recycling Center	Anahuac	TX	562213/ 924110	Hospital/Medical/Infectious Waste Incineration Facility	L	N	Yes
Wilkes-Barre General Hospital	Wilkes-Barre	PA	622110	General Medical and Surgical Hospital	M	N	No
Wyoming Medical Center	Casper	WY	622110	General Medical and Surgical Hospital	M	E	No
Yukon-Kuskokwim Delta Regional Hospital	Bethel	AK	622110	General Medical and Surgical Hospital	SR	E	No

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

Table 2-6. Industry by Type of Owning Facility

Category	Number of Incinerators	Annual Waste Throughput (tons)	Share of Waste (%)
Hospital	31	36,347	24.0%
Commercial	14	104,618	69.2%
Pharmaceutical	4	8,299	5.5%
University	4	766	0.5%
Government research	2	326	0.2%
Military installation	2	871	0.6%
Total	**57**	**151,228**	**100.0%**

Note: Annual throughput data are for 2002–2003. Percentages may not add to column total because of rounding.

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

2.4.2 Firm Characteristics

Table 2-7 presents data on the 45 parent companies and other entities owning the 57 HMIWI operating in the summer of 2008. Six of the HMIWI are federally owned: one by Department of Health and Human Services, one by the National Institutes of Health; two at veteran's hospitals; and two at Fort Detrick, the Army's biological and chemical weapons research facility. Fourteen are commercial, owned by five parent companies. The rest are owned by hospitals, universities, pharmaceutical companies, or other entities.

2.4.3 Ownership of HMIWI by Small Entities

To comply with requirements of the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), any small entities that own facilities affected by a proposed regulation must be identified. A small entity is defined as follows:

1. a small business according to Small Business Administration (SBA) size standards by the NAICS category of the owning entity;
2. a small governmental jurisdiction that is a government of a city, county, town, school district, or special district with a population of fewer than 50,000; or
3. a small organization that is any not-for-profit enterprise that is independently owned and operated and is not dominant in its field.

Table 2-7. Parent Companies of HMIWI Facilities

Parent Company	Year of Data	Parent Company Employment	Parent Company Sales (million)	Size Standards	Small Entity (2007)
Baptist Health Care Corp.	2007	5,200	$471	$31.5	No
Bayfront Health System	2007	2,018	$264	$31.5	No
Bethesda Healthcare Corp.	2007	1,602	$249	$31.5	No
BRCH Corp.	2007	1,400	$48	$31.5	No
Bristol-Myers Squibb Co.	2008	35,000	$20,597	750 employees	No
Camcare Inc.	2008	4,300	$773	$31.5	No
Catholic Health East	2007	50,000	$4,100	$31.5	No
Centers for Disease Control and Prevention	2007	Large	Large	None	No
Curtis Bay Energy	2008	50	$7	$11.5	Yes
East Carolina University	2007	5,078	$317	$6.5	No
Fairfield Medical Center	2007	2,200	$172	$31.5	No
Hamot Health Foundation	2007	2,032	$353	$31.5	No
Hawaii Health Systems Corp.	2007	3,400	$350	$31.5	No
Healthcare Waste Solutions, Inc.	2007	240	$15	$11.5	Borderline
Holy Spirit Health System	2007	2,400	$202	$31.5	No
Jefferson Health System	2007	20,700	$3,200	$31.5	No
Johns Hopkins Medicine	2007	7,000	$1,100	$6.5	No
Knox County Hospital Association	2007	1,600	$127	$31.5	No
Lakeland Regional Medical Center	2007	3,100	$479	$31.5	No
Loyola University Health System	2007	6,000	$282	$31.5	No
Mayo Foundation	2007	34,921	$7,400	$31.5	No
MedCentral Health System	2007	2,700	$265	$31.5	No
Medina Memorial Health Care System	2007	1,100	$31	$31.5	No
MedStar Health	2007	23,000	$2,900	$31.5	No
Merck & Co., Inc.	2008	55,200	$23,850	750 employees	No
MeritCare Health System	2007	1,500	$605	$11.5	No
Ministry Health Care	2007	12,000	$94	$31.5	No
MRI Center of Hollywood	2007	2,000	$93	$31.5	No

(continued)

Table 2-7. Parent Companies of HMIWI Facilities (continued)

Parent Company	Year of Data	Parent Company Employment	Parent Company Sales (million)	Size Standards	Small Entity (2007)
National Institutes of Health (NIH)	2007	Large	Large	500 employees	No
Parkview Health System	2007	4,500	$584	$31.5	No
Pennsylvania State University	2007	29,080	$3,266	$6.5	No
South Bend Medical Foundation Inc.	2007	800	$38	$31.5	Borderline
St. Jude Children's Research Hospital	2007	2,500	$418	$31.5	No
Stericycle, Inc.	2008	6,883	$1,084	$11.5	No
The University of Texas System	2007	77,627	$6,468	$31.5	No
Thomas Health Systems Inc.	2007	1,900	$123	$31.5	No
U.S. Army	2007	Large	Large	None	No
U.S. Department Of Veterans Affairs (US DVA)	2007	Large	Large	$31.5	No
University of Maryland	2007	23,316	$2,031	$6.5	No
Washington County Health System, Inc.	2007	2,500	$269	$31.5	No
Waste Management, Inc.	2008	45,900	$13,388	$11.5	No
Wyoming Medical Center Inc.	2007	1,033	$172	$31.5	No
Wyoming Valley Health Care System (WVHCS)	2007	3,500	$178	$31.5	No
Yukon-Kuskokwim Health Corp.	2007	1,800	$84	$31.5	No

Sources: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.
Dun and Bradstreet (DNB). 2007. Dun & Bradstreet 2007 Million Dollar Directory. Bethlehem, PA: Dun & Bradstreet, Inc.
Hoovers, a D&B Company. 2009. Obtained at <http://www.hoovers.com/free/> on July 1, 2009.

EPA's analysis supporting the proposed rule identified one small government that owned commercial HMIWI: Chambers County, Texas. The two units previously owned by Chambers County have since been purchased by Wheelabrator, a wholly-owned subsidiary of Waste Management, Inc. (a large firm). At proposal, three other entities were identified as borderline small; their sales, while above the small business threshold, were close enough that year-to-year variation in sales could cause them to fall below the threshold. One of these entities, Curtis Bay Energy, now meets the definition of a small business according to its most recent publicly available sales data.

Of the 57 incinerators units, two are owned by the same small company, and two are owned by two entities considered borderline small businesses. The two companies classified as borderline had sales revenues in 2007 above the small business size definitions for their NAICS, but were within a few million dollars of the size definitions; if the firms' revenues fall in future years, it is possible that their revenues could fall below the small business definition. One of the borderline small businesses owns commercially operated waste management facilities in Matthews, NC, while one is a hospital in Southbend, IN with a captive incinerator unit.

Curtis Bay Energy is a small business that owns two commercial incinerator units in Baltimore, MD. While it falls within the size definition of a small business, it has one of the largest volumes of HMIWI throughput in the country. In spite of the high throughput, Curtis Bay Energy's sales for 2008 were reported to be only $7 million. In comments submitted on the proposed rule, Curtis Bay Energy noted that they typically have a very low profit margin on their operations.

2.5 Markets

This section of the report briefly discusses market trends in the near future associated with incinerated medical waste, as well as information regarding volumes of current waste incinerated. It briefly touches on the regional monopolistic nature of the industry. Finally, it also discussed the current choices that waste generators face related to incineration treatment and other treatment methods (e.g., autoclave, microwaving) applied to medical waste.

2.5.1 Characterization of Medical Waste Management

Figure 2-3 shows the potential flow of medical waste from generator facilities to landfills. Waste generators can either treat waste on site or send it to a commercial waste treatment provider; waste can be treated by incineration (on site or off site), or an alternative treatment method (see Section 2.3.1 of the industry profile for alternative methods). While all of the HMIWI provide incineration treatment, only the 14 commercial units (located at 10 facilities owned by five parent companies/entities) participate in the market for HMIWI services. The captive/on-site HMIWI do not typically provide treatment for hospital/medical/infectious waste generated off site or by other firms. As the cost of incineration increases, medical waste generators will most likely shift the methods used to treat medical waste by taking advantage of alternative treatment methods, such as autoclaving, as well as training staff to segregate waste more effectively (Krisiunas, 2008). Generators of medical waste (both those with captive incinerators and those that send their waste to commercial HMIWI) have the opportunity and may have incentive to segregate their waste, to reduce the cost of treating their waste by

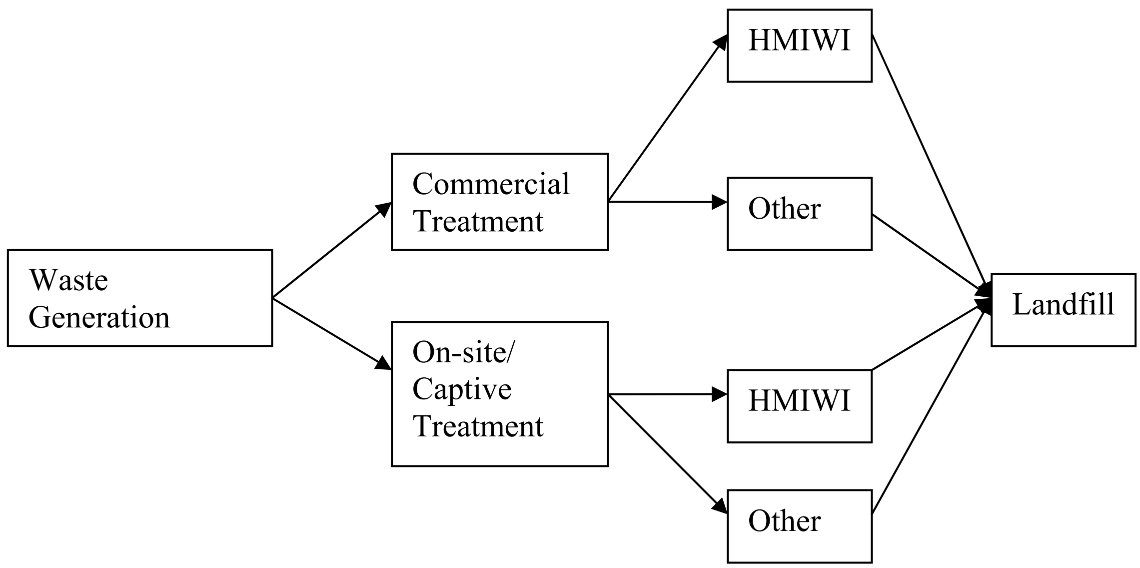


Figure 2-3. Structure of Waste Management Options

minimizing the amount of waste incinerated. Commercial HMIWI treat and dispose of waste from generators who do not have a large enough incentive to segregate their own waste (Stericycle, 2009). They are not easily able to segregate the waste after they receive it. This would increase the costs of commercial HMIWI, and expose their workers to potential risks.

Since the 1980s, increased regulation of hospital/medical/infectious waste treatment has increased the cost of incineration. During that period, the number of HMIWI units has decreased from over 2,000 incinerator units in the mid 1990s to 57 today. This has also caused a decrease in the percentage of medical waste incinerated from roughly 15% to a smaller share today. As mentioned earlier (Section 2.2.2), 2% to 3% of medical waste generated must be incinerated as a result of relatively higher liquid content of the waste. However, the actual percentage of medical waste sent to incinerators is most likely greater than 3% because of poor segregation practices.

Medical waste managers have reacted to the increased cost of incineration use by investing in captive alternative treatment capital equipment such as autoclaves. They have also reacted by contracting more commercial waste treatment companies to manage their waste. This second option is a more common alternative for waste generators because medical waste management is a very small portion of the total costs of operation.

2.5.2 *Regional Markets for HMIWI Services*

The total estimated waste throughput represented by commercial HMIWI units was over 104,000 pounds, which represents almost 70% of all medical waste incinerated. Captive incinerator units typically only incinerate waste that is produced by the captive hospital at which the unit is located. Treatment of the other 70% of waste generated by hospitals and other generating facilities that do not have captive HMIWI is distributed among the 14 commercial HMIWI units in the United States, located at 10 facilities, owned by five parent companies.

The geographic distribution of the 14 commercial units creates market power for facilities providing commercial treatment of medical wastes. The 10 commercial HMIWI facilities are spread across nine states. The locations of the HMIWI units become an issue when hospitals take into account transportation costs associated with transferring "red bag" waste to commercial incinerator units. More often than not, hospitals will prefer to patronize nearby incinerator units that result in lower transportation costs. Consequently, these commercial facilities have market power in regions that do not have strong incineration alternatives; only North Carolina has more than one commercial HMIWI facility. Figure 2-4 illustrates the distribution of commercial incinerator units.

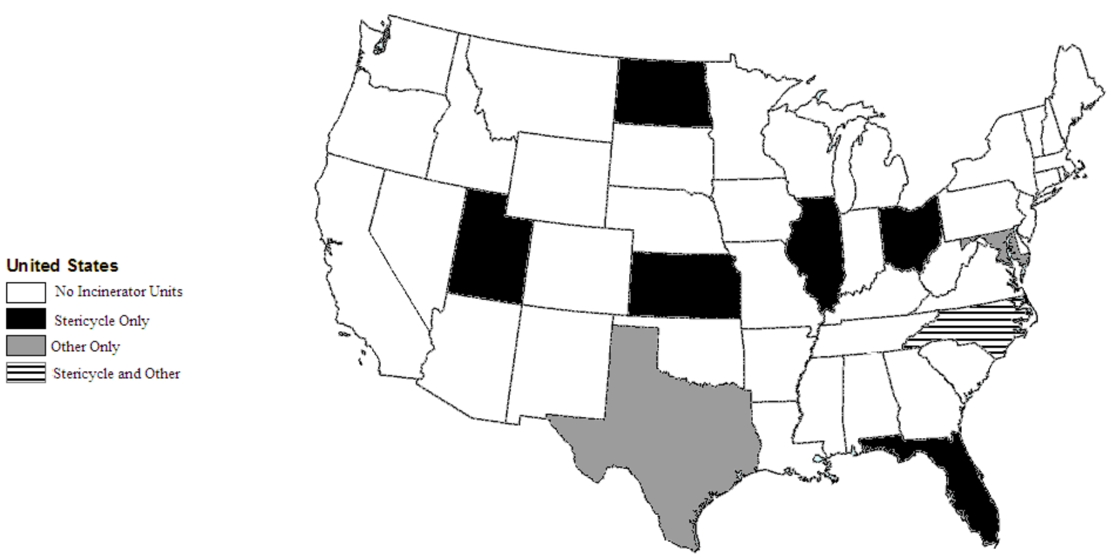


Figure 2-4. Regional Distribution of Commercial HMIWI

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

2.5.3 *Future Projections*

In 2003, the U.S. commercial medical waste management and service industry's revenue was $1.8 billion, and it is expected to rise at an average annual growth rate (AAGR) of 5.7%.

Since 1997, the use of incineration treatment has dramatically declined, with many hospitals and other generators closing their captive HMIWI and choosing to opt for off-site service until an alternative technology becomes more widely accepted (BCC Research, 2004).

The BCC Research study of trends in the medical waste management industry concludes that rising fees and increasing numbers of waste generating facilities and patients will support growth in the commercial service market. In 2003, 72.7% of infectious waste management revenue stemmed from the commercial service market, rather than the market for treatment or containment technologies. One alternative technology is liquid medical waste management, which is growing at an AAGR of 10.4% but is only expected to be responsible for 3.5% of the total infectious waste segment in 2008 (BCC Research, 2004). The study also noted increasing demand for waste-minimizing management methods such as reusable sharps containers.

A study conducted by Frost & Sullivan (2004) states that the present increase in the aging population will result in increased demand for medical waste management in the near future. Furthermore, enforcement of environmental regulations has shifted an increasing share of medical waste management to centralized, commercial service-providing facilities instead of captive waste treatment methods, including HMIWI, many of which have become outdated and unreliable.

This trend is supported by evidence from recently opened incineration facilities. In the past decade, five new or reconstructed units have been brought online, including one small federally owned unit at CDC. Of the other four, two are large units at a commercial facility, one is a reconstructed unit in a hospital, and the final one is a medium-sized unit at a community hospital. Thus, although many HMIWI units have been shut down in the past decade, several new ones, including considerable commercial capacity, have been brought online.

SECTION 3
COSTS OF COMPLIANCE FOR EXISTING AND NEW HMIWI

This section examines EPA's estimated costs of complying with the maximum achievable control technology (MACT) standards for existing and new HMIWI. Specifically, it compares and contrasts the costs of complying with the revised standards for six specific HMIWI owner types: commercial, government, hospital, military, pharmaceutical, and university. This section also discusses alternative methods of medical waste management to incineration in an effort to explain changes in behavior associated with the new costs.

3.1 Costs of Complying with the MACT Revisions for Existing HMIWI

The costs associated with the new MACT revisions for existing HMIWI include control costs, testing costs, record-keeping and reporting costs, and monitoring costs. The total annualized costs include capital costs of purchasing and installing new equipment, annualized over the expected lifetime of the equipment at 7%, as well as annual costs such as labor costs, materials costs, overhead, and other indirect costs. The costs are determined in the following manner:

- *Control costs* incorporate costs associated with installing the emission controls needed to curb emissions of pollutants in order to comply with the revised MACT standards for HMIWI.
- *Testing costs* primarily consist of costs that are incurred when conducting pollutant stack tests and visual emissions tests to demonstrate compliance with the revised MACT standards.
- *Record-keeping and reporting costs* entail costs associated with conducting performance specification tests for continuous monitoring systems (CMS), preparing notifications of performance tests and CMS demonstrations for submittal to EPA, reviewing reports of initial and annual stack tests, and conducting other record-keeping and reporting activities, all of which are used to document compliance with the revised MACT standards.
- *Monitoring costs* include costs of monitoring equipment and monitoring activities used to determine the effectiveness of emission controls in curbing emissions of pollutants from incinerators and demonstrate ongoing compliance with the revised MACT standards.

The largest control costs for HMIWI are incurred by the hospital (43%) and commercial (44%) owners of incinerators. The aggregate testing, record-keeping and reporting, and monitoring costs are lower for commercial incinerator owners than for hospital incinerator owners (Table 3-1). This is expected, given that the latter costs are imposed on each incinerator unit regardless of how much waste it treats; there are only 14 commercial incinerators compared to 29 hospital incinerators (Table 3-2). Per HMIWI unit, the testing, recordkeeping and reporting, and monitoring costs are similar across all ownership types (Table 3-3).

Table 3-1. MACT Costs by Owner Type

	Cost Associated with MACT Revisions				
Owner Type	**Total Control Cost**	**Total Monitoring Cost**	**Total Testing Cost**	**Total Record-Keeping and Reporting Cost**	**Total MACT Floor Cost**
Commercial	6,516,461	139,000	30,977	16,307	6,702,744
Federal	904,555	44,600	15,064	6,802	971,021
Hospital	6,418,738	224,600	114,575	39,547	6,797,459
Pharmaceutical	258,230	23,200	6,383	2,878	290,691
University	686,248	22,600	7,481	3,968	720,297
Total	**14,784,232**	**454,000**	**174,479**	**69,501**	**15,482,212**

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

Table 3-2. Waste and Facility Data

Owner Type	Estimated Throughput (tons/year)	Number of Affected HMIWI Units	Average Throughput Per Unit (tons)	Average MACT Floor Cost Per Ton of Waste Incinerated
Commercial	104,618	14	7,473	$81
Federal	2,867	6	478	$484
Hospital	34,677	29	1,196	$569
Pharmaceutical	8,299	4	2,075	$88
University	776	4	192	$1,017
Total	**151,228**	**57**	**2,653**	**$438**

[a] Waste throughput assumes facilities use two-thirds of HMIWI capacity.

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

Table 3-3. Average MACT Costs per Incinerator Unit by Owner Type

	Cost Associated with MACT Revisions				
Owner Type	**Average of Total Control Cost**	**Average of Total Monitoring Cost**	**Average of Total Testing Cost**	**Average of Total Record-Keeping and Reporting Cost**	**Average of Total MACT Floor Cost**
Commercial	$465,461	$9,929	$2,213	$1,165	$478,767
Federal	$150,759	$7,433	$2,511	$1,134	$161,837
Hospital	$221,336	$7,745	$3,951	$1,364	$234,395
Pharmaceutical	$64,558	$5,800	$1,596	$719	$72,673
University	$171,562	$5,650	$1,870	$992	$180,074
Total	**$259,372**	**$7,965**	**$3,061**	**$1,219**	**$271,618**

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

It is important to note that, although the average MACT floor cost for commercial incinerators is roughly two times greater than hospital-owned incinerators, the average quantity of waste incinerated by commercial incinerator units is more than six times greater than hospital incinerator units (Table 3-2). Thus, the MACT floor cost per ton is much lower for commercial units than for HMIWI owned by hospitals or universities.

Autoclaving and landfilling is an alternative treatment method to incineration for most types of infectious medical waste. As mentioned in the industry profile, between 2% and 3% of medical waste must be incinerated because it consists of waste with high liquid content that cannot be treated by autoclaving or any other alternative treatment method. Nevertheless, some waste generators may be able to achieve cost savings by investing in an autoclave and sending the majority of their hospital/medical/infectious waste to the autoclave, followed by landfill disposal. We report autoclaving/landfilling results because the revised MACT standards may cause some owners of HMIWI to consider alternative treatment methods such as autoclaving, to reduce their waste management costs.

Total estimated autoclave and landfill costs for each owner type are presented in Table 3-4. Again, the bulk of this cost would be incurred by commercial incinerator owners. However, Table 3-5's examination of cost per ton shows that the mean and median costs of autoclaving/landfilling as well as the control cost per ton/year is cheaper for commercial incinerator owners than any other type of owner. While the cost/ton for autoclave/landfill is lower for commercial HMIWI, the range of cost/ton across owner-types is relatively narrow,

Table 3-4. Autoclave/Landfill Cost by Owner Type

Owner Type	Throughput (tons/year)	Number of Units	Total Autoclave/ Landfill Cost	Autoclave/Landfill Cost Per Ton
Commercial	104,618	14	$7,233,837	$65
Federal	2,867	6	$213,842	$87
Hospital	34,677	29	$2,441,735	$84
Pharmaceutical	8,299	4	$681,420	$86
University	776	4	$66,402	$87
Total	**151,228**	**57**	**$10,637,237**	**$80**

Sources: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

unlike the range of MACT floor cost/ton. Although autoclave/landfill costs/ton for commercial HMIWI are lower than their MACT floor costs/ton, it is unlikely that commercial HMIWI operators will choose to divert all their hospital/medical/infectious waste stream to autoclave/landfill management; rather, their lower cost per ton for incineration may allow them to attract wastes that must be incinerated from captive owners for whom diversion of some waste to an autoclave coupled with commercial incineration of remaining wastes is their cost-minimizing solution.

It is important to note that the range for the total annualized MACT floor cost per ton varies widely within owner types as well as among owner types. For example, the minimum MACT floor cost per ton per year for hospital HMIWI owners is $20, while the maximum is $7,289. Thus, a single cost-minimizing response to the revised MACT standards may not be chosen by all the HMIWI owners of a single category.

Figure 3-1 shows a comparison between the mean autoclaving costs/ton and MACT floor costs/ton from Table 3-5. The autoclaving/landfilling cost is significantly cheaper for government, hospital, and university owners of incinerator units than the control costs associated with continued incineration. The average autoclaving/landfilling cost is greater than the control cost for incineration for commercial and pharmaceutical owner types.

Table 3-5. Descriptive Statistics by Owner Type: Cost and Cost per Ton for Autoclave/Landfill and MACT Floor Compliance

Owner Type	Descriptive Stat.	Autoclave/ Landfill Cost	Autoclave/Landfill per Ton/Yr	Total MACT Floor Cost	Total MACT Floor Cost per Ton/Yr
		Cost Associated with MACT Revisions			
Commercial	Mean	$516,703	$65	$478,767	$81
Federal		$35,640	$87	$161,837	$484
Hospital		$84,198	$84	$234,395	$569
Pharmaceutical		$170,355	$86	$72,673	$88
University		$16,600	$87	$180,074	$1,017
Commercial	Median	$301,097	$65	$320,568	$79
Federal		$28,412	$80	$201,937	$594
Hospital		$56,844	$80	$220,310	$185
Pharmaceutical		$82,518	$80	$57,177	$50
University		$14,983	$95	$224,371	$1,097
Commercial	Minimum	$61,244	$58	$1,096	$0
Federal		$15,197	$65	$3,211	$27
Hospital		$3,892	$58	$3,211	$20
Pharmaceutical		$46,413	$80	$1,096	$0
University		$13,555	$65	$1,096	$5
Commercial	Maximum	$1,660,043	$80	$1,653,093	$273
Federal		$90,255	$142	$264,378	$859
Hospital		$287,446	$149	$658,763	$7,289
Pharmaceutical		$469,971	$104	$175,240	$252
University		$22,880	$95	$270,457	$1,869

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

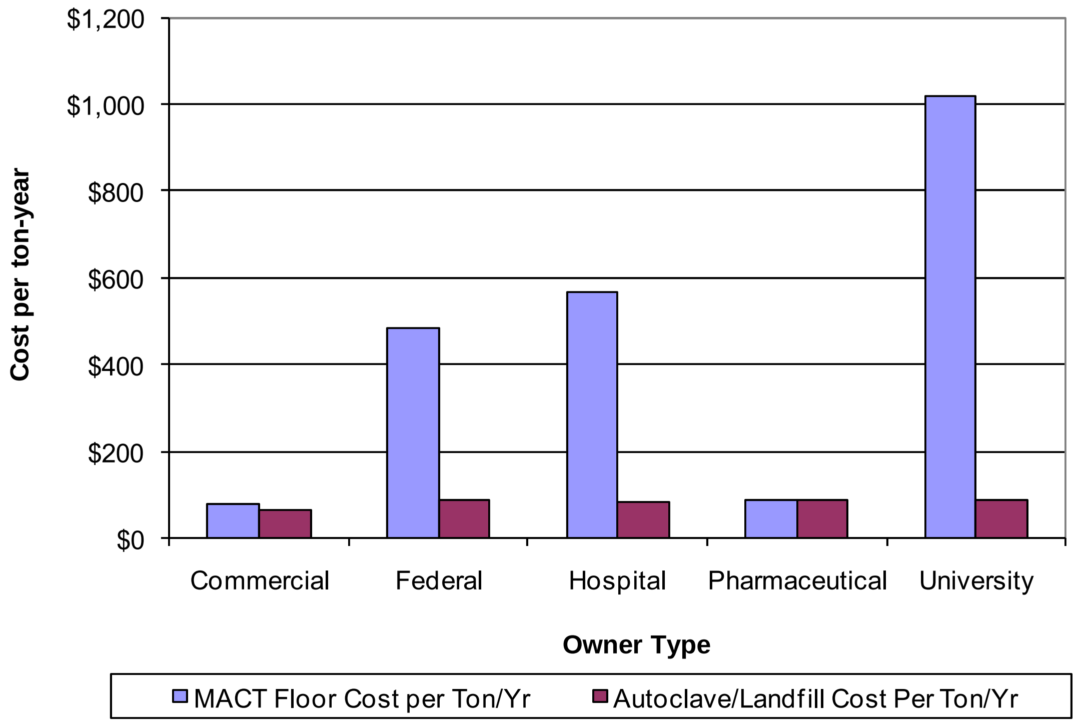


Figure 3-1. Mean Autoclaving/Landfilling Cost Compared to Control Cost for Incineration

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

3.2 Costs for New HMIWI Facilities

EPA estimated the costs for new HMIWI by developing small, medium, and large new model facilities based on the characteristics of HMIWI brought on-line during the past 10 years. Table 3-6 summarizes the estimated throughput and costs for these new model HMIWI.

Table 3-6. Estimated Costs for New HMIWI

New Model HMIWI	Estimated Throughput (tons/year)[a]	Autoclave-Landfill Cost ($/year)	Autoclave-Landfill Cost/Ton	HMIWI MACT Floor Cost ($/year)	HMIWI MACT Floor Cost/ton
New large	10,720	$729,858	$68	$1,083,290	$101
New medium	603	$49,964	$83	$115,576	$192
New small	101	$14,623	$146	$117,670	$1,171

[a] Waste throughput assumes facilities use two-thirds of HMIWI capacity.

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for New HMIWI.

Estimated MACT floor costs for new HMIWI are characterized by significant economies of scale; new large HMIWI have MACT floor costs of only $101 per ton, while new small HMIWI have MACT floor costs of $1,171 per ton. As with existing HMIWI, autoclave/landfill costs for new HMIWI are lower than MACT floor costs. While autoclave/landfill costs also exhibit economies of scale, the difference between costs for new large facilities and new small ones is less extreme. Although new autoclave/landfill costs are lower than new HMIWI costs for medium and small HMIWI (both in total and per ton treated) regulatory requirements may limit the ability of generators and treaters to substitute autoclave/landfill treatment for incineration, so there may continue to be demand for new HMIWI units.

SECTION 4
ECONOMIC IMPACTS ON EXISTING AND NEW SOURCES

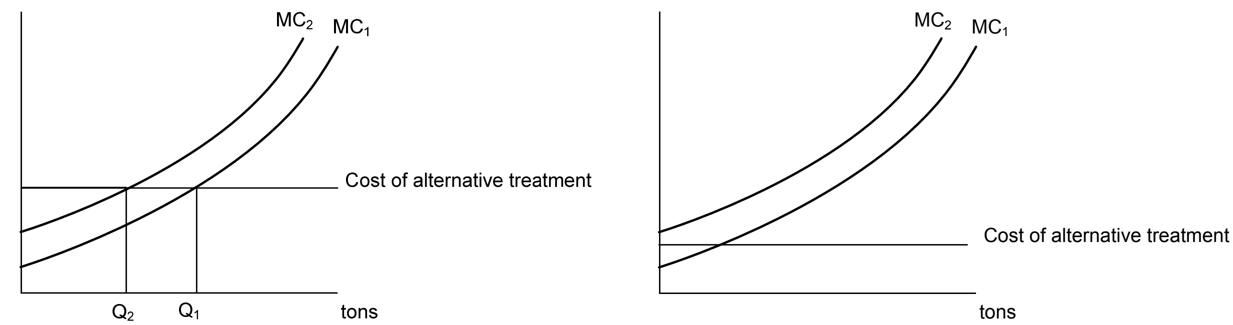
The revised standards for existing and new HMIWI will impose increased costs on facilities performing on-site incineration of hospital/medical/infectious waste. As described above in Section 2, the 57 HMIWI units currently operating include 14 commercially operated HMIWI, which accept waste from a variety of waste generators in several generating industries. In addition, there are 43 captive HMIWI, which incinerate waste generated on site at hospitals, pharmaceutical companies, universities, and research facilities. This section first examines likely responses and impacts for existing captive and commercial HMIWI and then examines the potential impacts on new HMIWI sources.

4.1 Impacts on Captive HMIWI

The 43 captive HMIWI include 31 hospital HMIWI, of which 2 are owned by the federal Department of Veterans' Affairs. Other federally owned HMIWI include two at federal research facilities and two at a military installation that studies biological and chemical weapons. Federally owned HMIWI are likely to have reasons to operate unrelated to market forces. Thus, EPA is not analyzing the impacts on federally owned facilities, beyond acknowledging the costs of compliance they may incur.

Not including the 6 federally owned facilities, there are 37 captive HMIWI, including 29 HMIWI at hospitals, 4 HMIWI owned by two pharmaceutical firms, and 4 HMIWI at universities. For each of the captive HMIWI, the owner's main business or function is not related to waste management, and the costs of operating the HMIWI, including costs of complying with the MACT standard, average less than 0.2% of parent company sales. The operators of captive HMIWI are also generators of hospital/medical/infectious waste that must be properly treated and disposed of. EPA expects owners of captive HMIWI to seek to minimize the cost of proper treatment of the waste they generate; this may include a mixture of on-site autoclave/off-site landfill, on-site incineration, and/or off-site commercial incineration. Figure 4-1 depicts possible responses by captive HMIWI owners faced with the costs of complying with the HMIWI rule. Complying with the revised MACT standards will increase the cost per ton of incinerating waste (shown as an upward shift in the HMIWI's marginal cost from MC_1 to MC_2).

Captive HMIWI have alternative treatment methods available to them, including autoclaving waste and sending the sterilized waste to an off-site landfill, or sending the waste to a commercial HMIWI. Because guidelines for managing hospital/medical/infectious waste



a) Generator reduces the volume incinerated. b) Generator closes HMIWI, uses alternative treatment.

Figure 4-1. Impacts of Costs for Captive HMIWI

require incineration treatment of chemotherapy residuals and body fluids, relative cost is not the only consideration for hospital/medical/infectious waste generators operating captive HMIWI. Even if autoclave/landfill is the lowest-cost alternative treatment, operators of captive HMIWI may not choose to send all their waste to an autoclave/landfill.

Operators of captive HMIWI will, however, compare the cost of continuing to operate their HMIWI with the cost of alternative treatment. Figure 4-1a depicts a situation where the costs of incineration increase to the extent that the generator diverts some of its waste stream to alternative treatment (either autoclave/landfill or commercial HMIWI), reducing the amount of waste it incinerates. This could be accomplished through more stringent segregation of waste so that only the waste that must be incinerated is sent to the HMIWI. Figure 4-1b depicts a situation where a captive HMIWI's costs increase sufficiently that, at all volumes of throughput, the cost of continuing to operate the HMIWI exceeds the cost of alternative treatment. A firm operating a captive HMIWI facing this situation would choose to shut down the HMIWI and send all the waste it generates to alternative treatment. Over the past 15 years, there has been a substantial reduction in the number of HMIWI units; as the costs of operating captive HMIWI increase in response to the HMIWI MACT standards, additional captive HMIWI may shut down.

Because the cost of managing their hospital/medical/infectious waste is a very small share of the cost of the overall operations of hospitals, research facilities, pharmaceutical facilities, and universities, EPA does not expect the revised MACT standards to significantly affect the markets for these underlying generator activities. Instead, EPA expects very small changes or no changes in prices and quantities for the products and services that generate the waste (see Figure 4-2). For purposes of the analysis, EPA will assume that owners of captive

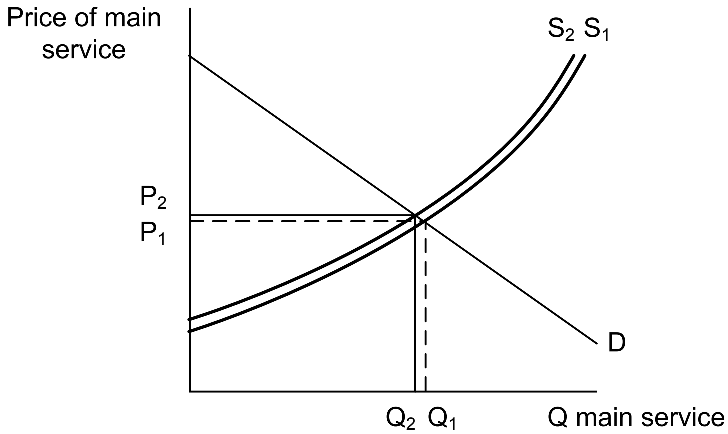


Figure 4-2. Minimal Impacts on Markets for Generators' Services

HMIWI will absorb the cost of complying with the revised MACT standard and will not pass any share of it along to consumers of their main products or services.

This approach implies that the owners of captive HMIWI will choose to continue to operate the HMIWI and will thus incur the costs of complying with the revised HMIWI MACT standards. EPA recognizes, however, that these generators have several options available to them: depending on the composition of their hospital/medical/infectious waste stream, they may be able to divert some of their waste to other on-site treatment technologies, such as autoclaving and then sending the waste to an off-site landfill. Alternatively, they may choose to close their HMIWI and send their waste to a commercial HMIWI. EPA's estimate of autoclaving and landfilling costs indicates that these costs are uniformly lower than the costs of incineration, even without including the costs of complying with the HMIWI rule. The fact that these generators are choosing to continue to operate their HMIWI suggests that there are underlying factors that motivate this choice. For example, it is likely that a subset of the generators' waste stream consists of waste types for which autoclaving and landfilling is not adequate treatment. It may be that the cost of improved waste segregation practices, which would enable the generators to increase the share of their waste stream that is autoclaved, exceed the cost of incineration. Thus, the conservative approach of comparing captive HMIWI operators' MACT floor compliance costs to their company revenues, which would assume they continue to operate their HMIWI, may be realistic even though it appears they may have less costly alternatives.

Another source of potential cost savings is the use of a waste heat recovery boiler. Waste heat recovery boilers are currently being used in at least 47% of all HMIWI units (53% of captive units, 29% of commercial). These boilers enable HMIWI operators to recover energy in the form of steam generated by the incinerator. This steam may be delivered to turbines, which could heat the building and offset some of the costs of operating the incinerator.

Examination of the costs of complying with the revised HMIWI MACT standards, compared with the estimated cost of commercially treating the waste currently being incinerated in captive HMIWI, shows that for at least some of the 39 captive HMIWI[1] for which off-site treatment is believed to be possible, off-site incineration may be less costly than complying with the rule. However, the analysis omits transportation costs, which could tip the balance back toward on-site captive treatment. Thus, while there may be less costly alternative treatment options available for at least some of the waste currently incinerated in on-site captive HMIWI, EPA has chosen to measure the impacts on these HMIWI owners by comparing the costs of complying with the revised HMIWI MACT standards to their company sales, because this is a worst-case full-cost absorption approach that is expected to be the maximum cost they would face to treat their hospital/medical/infectious waste.

4.2 Impacts on Commercial HMIWI

Unlike firms owning captive HMIWI, firms owning commercial HMIWI are in the business of commercial incineration of waste generated off site. The costs of incineration are a major share of the total costs of these firms. Compliance with the revised MACT standards will increase the costs of these facilities also, shifting their supply curves up.

At the same time, EPA expects the diversion of some hospital/medical/infectious waste previously treated by captive HMIWI to commercial treatment. Hospitals and other generators may choose to close their HMIWI rather than comply with the rule. At least a portion of their waste would then be sent to commercial HMIWI for treatment, thus increasing the demand for commercial HMIWI services. Figure 4-3 depicts the changing conditions in the market for HMIWI services.

The with-regulation market for HMIWI services will clearly be characterized by higher prices. Both the increase in demand and the increase in the costs of providing HMIWI services tend to increase the market price for these services. Whether the with-regulation market quantity of HMIWI services is higher or lower than the without-regulation quantity depends on the relative shifts and price-responsiveness of the supply and demand functions.

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[1]The 39 HMIWI for which off-site commercial treatment would be possible include 37 privately owned HMIWI plus two HMIWI at VA hospitals.

4.2.1 Assumed Commercial HMIWI Market Characteristics

As described in Section 2, the markets for HMIWI services are regional, and there are at most two commercial HMIWI facilities directly competing with one another. The commercial HMIWI industry is quite concentrated. Nationwide, there are 14 commercial HMIWI units, at 10 facilities, in 9 states, owned by 5 entities. Stericycle, a leading commercial supplier of HMIWI services, owns 6 of the 10 commercial HMIWI facilities. In reality, prices for HMIWI services

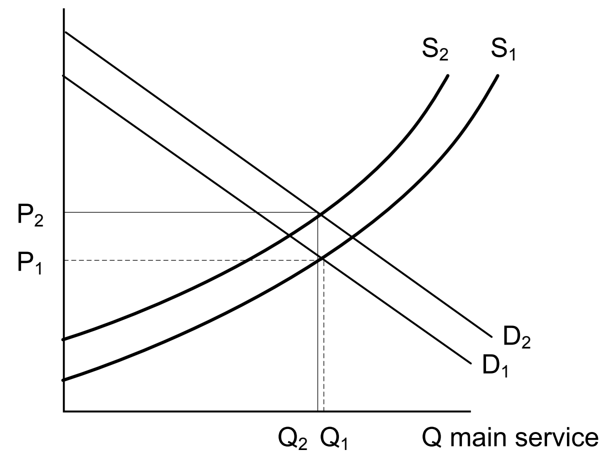

Figure 4-3. Impact on Market for Commercial HMIWI: Supply Decreases, Demand Increases

may vary from load to load based on the load's contents; in addition, prices quoted to customers frequently include supplies, transportation, and other services, as well as incineration. However, EPA's analysis focuses on the incineration services only. For simplicity, we are modeling the market impacts as if the commercial HMIWI are regional monopolists, able to set their prices based on the demand for their services and the costs of supplying the services. Given the small number of suppliers and the differentiated nature of the services, this is not an unreasonable assumption.

4.2.2 Analytical Approach for Estimating Commercial HMIWI Impacts

EPA has combined publicly available data with engineering estimates to develop models of the commercial HMIWI facilities. Under the simplifying assumption that the commercial HMIWI operate as regional monopolists, EPA estimated the market impacts using a model of monopoly pricing. Based on the with-regulation cost of treatment, the commercial HMIWI identify the most profitable new price and quantity for their service from the market demand for the service. The monopolist chooses a price and output that maximizes its profit. The choice of price and output depends on the behavior of customers as reflected in the price-responsiveness of the demand curve facing the firm.

The monopolist's profit-maximizing level of output of input i occurs where his marginal revenue equals marginal cost, or

$$MR_i = P_i\,(1+1/n_i) = MC_i, \tag{4.1}$$

where MR_i = marginal revenue per ton of HMIWI services, input i,
P_i = market price of HMIWI services ($/ton),
n_i = elasticity of demand for HMIWI services "i," and
MC_i = marginal cost of HMIWI services, "i" ($/ton).

Because EPA modeled the markets for HMIWI services as regional monopolies, a moderate price elasticity, −1.2, was used. Monopolists have sufficient market power to adjust their prices to maximize their profits. One commercial HMIWI firm, Curtis Bay Energy (CBE), submitted a comment in response to the proposed rule that indicates that their market demand is more elastic. CBE operates two HMIWI units in Baltimore, MD. Together, their two HMIWI units treat more than 40,000 tons per year (43% of the total volume of commercial HMIWI waste treated). In their comment, they state that the majority of the waste they treat comes from generators who would choose to use alternative treatment methods if the price of CBE's HMIWI treatment increased substantially. As a result, they state that they are able to charge market prices for their services that are only slightly higher than their costs of treatment, so that they earn only a small profit margin on much of the waste they treat. To reflect these conditions, the market analysis assumes an elasticity of demand for CBE's market of −10.

In each market, EPA estimates baseline market price based on baseline unit costs of HMIWI services and the assumed price-elasticity of demand, generally −1.2. With units' baseline HMIWI operating costs ranging from $81/ton to $593/ton, estimated baseline prices range from $510/ton to $3,558/ton.[2]

EPA does not have data on the elasticity of demand for HMIWI services. In the absence of such data, EPA used economic reasoning and empirical evidence from other waste management markets to estimate a reasonable value for the elasticity of demand for HMIWI services. HMIWI services are inputs, similar to materials, labor, or energy, into the production of

[2]Information from a generator located in the Northeastern United States indicates that their cost of total hospital/medical/infectious waste management services averaged $972/ton in 2007.

the goods or services produced by generators, such as hospitals or pharmaceutical firms. The demand for the HMIWI input is derived from the demand for the final goods and services produced by the generators.

Several authors have conducted empirical studies of the price-responsiveness of demand for waste management services of various kinds (Levinson, 1997; Alberini, 1997; Sigman, 1998). Their studies provide evidence that the demand for waste management services is slightly to moderately responsive to changes in its price, and many other factors also affect demand for the services.

Faced with the cost of complying with the revised HMIWI MACT standards, commercial HMIWI will increase the price of their services. Consider a HMIWI with constant marginal costs (MC), which incurs costs (c) to comply with the revised HMIWI MACT standards. The marginal cost curve shifts up by the amount of the unit compliance cost to (MC + c), and the intersection of marginal revenue with marginal cost moves to the left, reflecting a reduction in quantity treated. The magnitude of the shift in quantity depends on the shape of the demand curve. EPA has chosen to use a constant elasticity demand curve of the form $q = Cp^n$, where n is the price-elasticity of demand and C is a constant.[3] Given this demand curve, the MR = MC condition can be rewritten. The new price may be computed as

$$P_2 = (MC + c) / (1 + 1/n). \tag{4.2}$$

As indicated by this equation, a monopolist facing a constant elasticity demand curve will charge a price that is a constant markup on marginal cost given by 1/(1 + n). Given that the demand elasticity must be elastic (greater than or equal to one in absolute value), the constant markup is greater than one so that the monopolist passes on more than the amount of the unit compliance cost to consumers. Thus, to operationalize a monopolist facing a constant elasticity demand function, the model specifies the parameters of the demand function (C and n) and determines the new market price using Equation 4.3. Finally, the model then computes the new equilibrium quantity of HMIWI services in the market by solving the market demand equation given the new market price (Equation 4.3).

$$q_2 = CP_2^n. \tag{4.3}$$

[3]Although CBE's comment on the proposed rule indicated that their price-elasticity of demand varies depending on the customer type, for simplicity this analysis assumes a more elastic demand curve than that facing other commercial HMIWI, with a higher (in absolute value) constant value.

4.3 Results of Impact Analysis for Existing Facilities

As described above, different methods are used to analyze the economic impacts of the revised HMIWI MACT standards on captive and commercial HMIWI. This section reports the results of EPA's analysis of potential impacts on these two groups of HMIWI.

4.3.1 Estimated Economic Impacts on Owners of On-Site Captive HMIWI

Impacts on owners of captive HMIWI are measured by comparing the costs of complying with the revised HMIWI MACT standard to the revenues of the parent company that owns the HMIWI. Table 4-1 shows the results by type of owner (hospital, university, pharmaceutical firm).

Table 4-1. Estimated Impacts for Firms Owning Captive HMIWI[a]

	MACT Cost-to-Sales Ratio				
HMIWI Owner Type	**Minimum**	**Maximum**	**Median**	**Average**	**Autoclave/ Landfill**
Hospital (29 firms)	0.002%	0.995%	0.041%	0.143%	0.290%
Pharmaceutical manufacturer (2 firms)	0.000%	0.001%	0.001%	0.001%	0.003%
University (4 universities)	0.000%	0.025%	0.009%	0.011%	0.004%

[a] In addition to the firms listed, the federal government owns two HMIWI at Veterans Administration hospitals, two HMIWI at Fort Detrick, one HMIWI at the Centers for Disease Control and Prevention, and one HMIWI at Rocky Mountain Laboratories. EPA assumes that they will continue to operate and will absorb the costs of complying.

Sources: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.
Dun and Bradstreet (DNB). 2007. Dun & Bradstreet 2007 Million Dollar Directory. Bethlehem, PA: Dun & Bradstreet, Inc.
Hoovers, a D&B Company. <http://www.hoovers.com/free/>

The cost-to-sales ratios reported in Table 4-1 measure the estimated impacts of complying with the revised HMIWI MACT standards and continuing to operate the HMIWI, which are generally the highest estimated costs expected to be incurred by owners of captive HMIWI. In fact, EPA's analysis suggests that some owners of captive HMIWI may be able to reduce their costs of compliance by diverting some of the waste they are currently incinerating on site to on-site autoclave treatment and then landfill disposal, or by closing their HMIWI and sending the waste to commercial treatment. The final column in Table 4-1 shows maximum cost-to-sales ratios, by owner type, for on-site autoclaving followed by off-site landfill disposal. As is shown by these ratios, autoclaving followed by off-site landfill is frequently a lower-cost treatment option, relative to on-site incineration. This would suggest that, even at baseline, owners of captive HMIWI could reduce hospital/medical/infectious waste management costs by diverting some of their waste to autoclaving/landfilling. Two factors may have caused them not to maximize the quantity of waste sent to autoclave treatment at baseline:

- Minimizing the quantity of waste sent to the HMIWI and sending a higher proportion to the autoclave would require stringent waste segregation. The cost of staff time associated with this activity may exceed the baseline cost savings from diversion.
- Some wastes must be incinerated, so even if autoclaving is less costly, it is not a viable treatment option for all wastes.

The increased costs of HMIWI treatment resulting from the revised MACT standards may change the cost calculus described in the first bullet; however, diversion to autoclave treatment and landfill disposal will remain limited by the second bullet.

4.3.2 Estimated Economic Impacts on Owners of Commercial HMIWI

EPA estimated the economic impacts on owners of commercial HMIWI using the market model as described above. EPA identified 10 existing commercial HMIWI facilities, owned by 5 companies, operating HMIWI 14 units in 9 states. EPA modeled the impacts on these HMIWI as if they operated as regional monopolies. This modeling approach assumes that each of these commercial HMIWI facilities serves a unique set of customers, which are generally defined geographically (that is, generators tend to send their hospital/medical/infectious waste to the commercial HMIWI located closest to them). Table 4-2 presents baseline data for these commercial HMIWI.

Complying with the revised HMIWI MACT standards will increase these commercial HMIWI's costs of control, monitoring, testing, recordkeeping, and reporting. Table 4-3 shows these firms' compliance costs, estimated with-regulation volume treated, estimated with-regulation price charged, and estimated with-regulation profit. Each firm is estimated to increase their prices by more than their compliance costs. Table 4-3 shows that commercial HMIWI are estimated to increase their prices by more than their costs have increased; as a result, their per-ton profit is estimated to increase from an average $400/ton to an average $887/ton.

Table 4-2. Estimated Baseline Conditions for Commercial HMIWI Facilities and Markets

Commercial HMIWI Facility[a]	Estimated Waste Throughput (tons)	Estimated Baseline Operating Costs ($/ton)	Estimated Baseline Price ($/ton)	Estimated Baseline Profit (10^3 $2007)
Stericycle, Inc., Apopka, FL	5,061	188	1,129	4,760
Stericycle, Inc., Warren, OH	3,707	81	488	1,506
Stericycle, Inc., Kansas City, KS	4,402	87	521	1,910
Healthcare Environmental Services Inc., Fargo, ND	1,057	593	3,558	3,135
Stericycle, Inc., North Salt Lake, UT	4,738	159	957	3,778
Wheelabrator/WMI, Anahuac, TX	22,045	119	712	13,076
Curtis Bay Energy, Baltimore, MD	41,458	183	203	843
Stericycle, Inc., Haw River, NC	10,755	84	504	4,517
BMWNC, Inc., Matthews, NC	3,747	246	1,474	4,602
Stericycle, Inc., Clinton, IL	7,649	98	588	3,748
Total for Commercial HMIWI	**104,618**			**41,876**

[a] Although the names of actual commercial HMIWI are used, the data are for model facilities used to represent typical HMIWI with similar characteristics; the models were created by combining publicly available data with engineering and economic models.

Source: Holloway, T. June 19, 2009. Revised Baseline Operating Costs for Existing HMIWI.

Table 4-3 shows that, in response to the revised HMIWI MACT standards, commercial HMIWI will increase the prices they charge and their per-ton profits. Faced with higher prices, the customers of commercial HMIWI will reduce the quantity of waste they send for incineration. Because the quantity of hospital/medical/infectious waste received for treatment declines, EPA's analysis estimates that aggregate profits (as well as aggregate treatment costs and aggregate incineration revenues) for these commercial HMIWI would decline. Referring to Figure 4-3, the impacts measured by the analysis are only those resulting from the upward shift of the facilities' supply curves due to the costs of complying with the revised HMIWI MACT standards.

Table 4-3. Estimated With-Regulation Conditions for Commercial HMIWI Facilities and Markets

Commercial HMIWI facility	Estimated Waste Throughput (tons)	Estimated Total Annualized MACT Costs ($/ton)	Estimated With-Regulation Operating Costs ($/ton)	Estimated With-Regulation Price ($/ton)	Estimated With-Regulation Profit (10^3 $2007)
Stericycle, Inc., Apopka, FL	3,704	56	244	1,464	4,518
Stericycle, Inc., Warren, OH	1,631	80	161	967	1,314
Stericycle, Inc., Kansas City, KS	1,922	86	173	1,039	1,664
Healthcare Environmental Services Inc., Fargo, ND	671	273	866	5,195	2,906
Stericycle, Inc., North Salt Lake, UT	3,663	38	198	1,186	3,620
Wheelabrator/WMI, Anahuac, TX	19,599	12	131	785	12,822
Curtis Bay Energy, Baltimore, MD	1,283	76	259	288	37
Stericycle, Inc., Haw River, NC	4,876	78	162	974	3,959
BMWNC, Inc., Matthews, NC	2,650	82	328	1,967	4,344
Stericycle, Inc., Clinton, IL	3,336	98	196	1,174	3,264
Total for Commercial HMIWI	**43,336**				**38,448**

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

EPA expects that some captive HMIWI will choose to shut down rather than comply with the revised MACT standards, and that some of the waste they are currently treating on-site by incineration will be sent to commercial HMIWI. As a result, some increase in quantity treated and market price is likely to occur, relative to the results reported in Table 4-4. However, because of uncertainties and data limitations, EPA has not attempted to identify which commercial HMIWI may realize increased demand, and has not attempted to quantify the impacts of this shift in demand, beyond a broad assessment.

Table 4-4. Estimated With-Regulation Change in Commercial Facility Finances

	Estimated Change in Waste Throughput (tons)	Estimated Change in Costs (10^3 $2007)	Estimated Change in Revenues (10^3 $2007)	Estimated Change in Profit (10^3 $2007)
Minimum	−40,174	−7,256	−8,062	−806
Maximum	−386	−32	−190	−159
Median	−2,261	−50	−300	−250
Average	−6,128	−778	−1,121	−343
Total	**−61,282**	**−7,780**	**−11,208**	**−3,428**

As mentioned above, it is possible that some of the current captive HMIWI may choose to divert some of their waste to commercial treatment. Comparing captive facilities' costs of compliance with the revised HMIWI MACT standards to their costs of treating their waste commercially, commercial HMIWI treatment appears to be less expensive. (However, these computations compare treatment costs only; they do not include transportation or other costs of commercial treatment.) Nevertheless, it appears that for some captive HMIWI, more stringent segregation, increased on-site autoclave treatment followed by landfill disposal, and use of commercial treatment for their remaining hospital/medical/infectious waste may be the cost-minimizing choice. After examining with-regulation captive treatment costs and estimated commercial treatment costs, EPA estimates that perhaps as much as 7% of baseline captive quantity treated may be diverted from captive to commercial treatment when the revised HMIWI MACT standards take effect. This increase in demand will partially offset the reduction in quantity treated that is shown in Table 4-4. To illustrate these potential impacts, if 7% of baseline captive treatment is diverted from captive to commercial treatment under the revised HMIWI MACT, the with-regulation quantity treated would be approximately 46,200 tons rather than 43,300 tons. The increased demand would also result in an increase in the price of commercial treatment averaging about 5%, in addition to the increases in price described in Table 4-3. Under these assumptions, commercial HMIWI would realize an additional $3.36 million in profits, largely offsetting the $3.43 million reduction in profits described above, and in Table 4-4.

4.4 Estimated Social Costs of the Revised HMIWI MACT Standards for Existing Sources

EPA estimates the social costs of the rule by summing the change in consumers' surplus and the change in producers' surplus. Social cost differs from the sum of total annualized cost of compliance because it takes into account market adjustments in response to the rule. For owners of captive HMIWI, the change producers' surplus is equal to the estimated HMIWI MACT standards costs: we assume that they will absorb these costs and that their prices and main production activities will be unchanged. Thus, their profits will be reduced by the amount of their MACT costs.

Consumer and producer surplus changes in the market for HMIWI services are approximated using the computations shown below:

$$\text{Social Cost} = \Delta CS + \Delta PS \tag{4.4}$$

$$\Delta CS = \Delta P^*Q_2 + ½^*\Delta P^*\Delta Q$$

$$\Delta PS = \Delta \text{Profit}$$

Captive HMIWI MACT costs total approximately $8.8 million per year. For commercial HMIWI, the change in consumer surplus is approximately $18.6 million, and the change in producers' surplus equals approximately $3.4 million. Overall, the social cost of the revised HMIWI MACT standards is estimated to be approximately $30.8 million.

4.5 Impacts on Small Entities of the Revised HMIWI MACT Standards for Existing Sources

Under the RFA as amended by SBREFA, EPA must evaluate potential impacts to small entities resulting from its actions. Small entities may be defined as (1) a small business, as defined by SBA's regulations at 13 CFR Part 121.201 (SBA, 2008); (2) a small governmental jurisdiction that is a government of a city, county, town, school district, or special district with a population of less than 50,000; or (3) a small organization that is any not-for-profit enterprise that is independently owned and operated and is not dominant in its field.

EPA assessed the possible impacts of the revised HMIWI MACT standards for existing sources on small entities. EPA first gathered data on firms and other entities that own existing HMIWI. Omitting those HMIWI owned by the federal government (six HMIWI units at five facilities), there are 39 firms that own existing HMIWI units. Of the 39 owner firms, only one, Curtis Bay Energy, qualifies as a small entity based on guidance from the SBA and EPA's 2006 Final SBREFA Guidance (EPA, 2006) and sales/revenue data collected. Two other entities are defined as borderline small: their parent company sales or employment are above the SBA size-cutoff for small entities in their NAICS codes, but are near enough to the size cut-off that variations in sales or employment over time might move them below the small business criterion. The rest are large firms.

To measure the size of the potential impacts of the revised HMIWI MACT standards on firms and other entities owning existing HMIWI, EPA compared the total annualized compliance cost for all HMIWI owned by a firm to the annual sales or other revenues received by the firm. The firm's revenues provide an indication of its capacity to pay the costs of complying with the rule. Table 4-1 above shows statistics for cost-to-sales ratios for firms owning captive HMIWI. The maximum cost-to-sales ratio for these firms is 0.995%. Thus, none of the firms owning captive HMIWI are likely to incur significant impacts.

Impact measures for the five entities owning commercial HMIWI are shown in Table 4-5. The cost-to-sales ratios are generally higher than for owners of captive HMIWI. This is because commercial HMIWI treat much higher volumes in general than do captive HMIWI and thus face larger costs of complying with the rule. Waste management is their business and costs of waste management are a very large share of their total costs of operation, unlike hospitals, universities, and pharmaceutical firms. Among the five owners of commercial HMIWI, three are large businesses: Stericycle, Wheelabrator/Waste Management Inc., and MeritCare Health Systems. One is a small firm (Curtis Bay Energy), and the other one, BMWNC, is a borderline small business. Note that these results do not reflect market responses to the costs discussed above.

Table 4-5. Impacts on Owners of Existing Commercial HMIWI

Owner	Sales or Revenues ($\$10^3$ 2007)	Small Entity Size Criterion	Estimated HMIWI MACT TAC ($\$10^3$ 2007)	Estimated Cost-to-Sales or Revenue (%)
Healthcare Waste Solutions	$15,000	$11,500	308	2.0
Wheelabrator/Waste Management Inc.	$13,888	$11,500	269	0.002
Curtis Bay Energy	$7,000	$11,500	3,154	45.1
MeritCare Health Systems	$605,000	$11,500	289	0.05
Stericycle	$1,084,000	$11,500	2,683	0.25

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for Existing HMIWI.

Because they have some market power, commercial HMIWI have the ability to increase the price charged for their services by more than their total annualized compliance costs, so that their per-ton profits are actually increased although their gross profit declines. Thus, even though the costs are a large share of sales for these owners, including the small business, Curtis Bay Energy, they have the ability to pass the costs, plus a mark-up, along to their customers and are thus expected to be able to afford compliance.

Curtis Bay Energy, in particular, faces costs that are estimated to be a substantial share of their revenues (45.1%). Even though the analysis, which assumes constant demand elasticity and a monopolistic market structure, predicts that CBE would be able to increase the price of their services sufficiently to cover the costs of compliance, CBE's comments on the proposed rule (discussed in greater detail below) suggest that they may be competing with non-HMIWI treaters for at least a share of their customers. Because of this they state they may not be able to raise their prices sufficiently to stay profitable after compliance.

Curtis Bay Energy is faced with a unique situation because of their designation as a small business, coupled with their high volume of waste throughput. The estimated total sale for CBE in 2008 was $7 million (Hoovers, 2009). With an estimated incineration throughput of 41,458 tons, their revenue per ton incinerated is thus estimated to be $168. Though not a small entity, the next smallest parent company is Healthcare Waste Solutions with total sales estimated at $15 million. This company owns an incineration unit operated by BMWNC Inc. with revenue per ton incinerated equal to $4,003. It must be noted that the primary service offered by Curtis Bay Energy, and thus the main source of its sales, is waste treatment via incineration. Other commercial entities have more diverse sources for sales.

Another consideration for CBE's market analysis involves the price elasticity of demand for incineration services. Incinerated waste throughput at CBE attracts more than a third of the total waste throughput for commercial facilities as demonstrated in Table 4-2. CBE asserts that they serve a diverse set of customers whose demand structures are more complex than exhibited in Figure 4-3 (2009). In their comments, CBE noted that there are at least three types of customers that they serve, with varying degrees of price elasticity of demand (CBE, 2009). The first type includes those customers who either require or prefer incineration to other methods of waste treatment. As a result, the leftmost portion of the demand curve (A) is fairly steep (Figure 4-4). The middle portion (B) includes all waste generators that are indifferent between methods of waste treatment, and will make decisions based on cost alone. The demand curve for these customers is represented by a more elastic segment, causing even a small change in prices

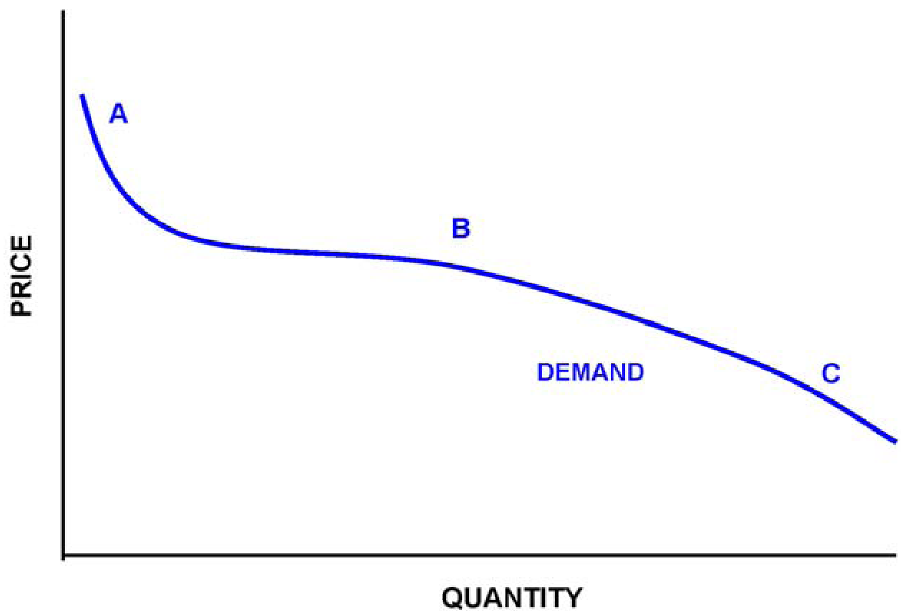

Figure 4-4. Customer Demand for Waste Incineration at CBE

Source: CBE, 2009.

to significantly affect the quantity of waste supplied. Finally, the last segment of the curve includes large medical generators (i.e., hospitals), that generally have cheaper alternatives to waste treatment.

Profits generated by CBE are marginal at baseline because they set low prices in order to attract large amounts of waste throughput. Significant increases in their cost of operation may reduce their ability to generate profit. According to CBE, many of their customers fall under the second category of waste generators who will quickly seek alternative means of waste treatment. Thus, large increases in their cost of operation may result in a situation where it will not be profitable for CBE to serve any of the customer types mentioned above (Figure 4-5).

There may be considerable variability from year to year in firm sales and costs, and thus in firm profitability. Thus, even firms projected to have positive profits may occasionally experience years when they are unprofitable.

EPA does not have sufficient information about the financial status of this firm to be certain that they would not encounter difficulties in complying with the rule. For example, even if CBE were able to raise their prices sufficiently to cover the costs of compliance, they might have difficulty obtaining capital to finance lump-sum expenditures on controls.

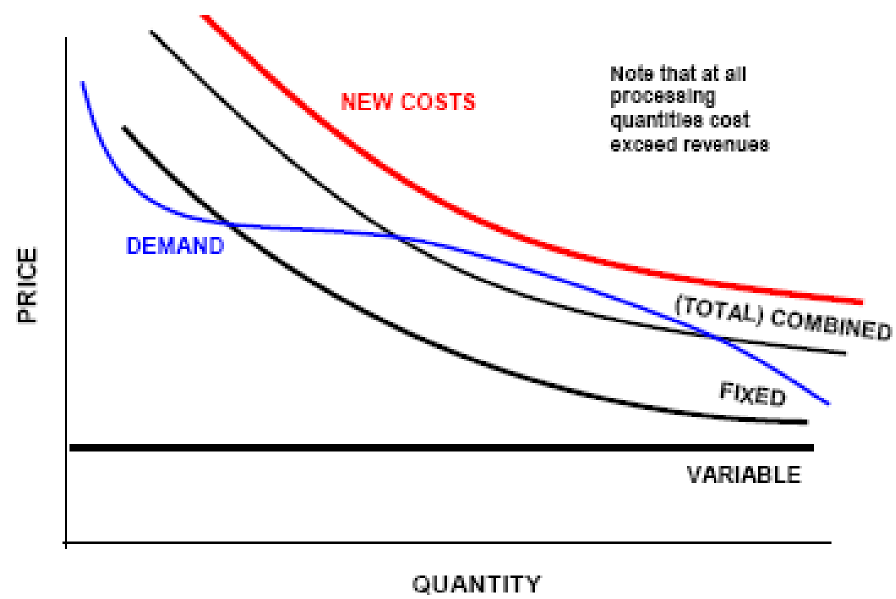

Figure 4-5. Supply and Demand Structure for CBE Including New Costs

Source: CBE, 2009.

4.6 Impacts on New HMIWI

In addition to emission guidelines that would necessitate additional controls, monitoring, recordkeeping, and reporting for existing sources, EPA's revised HMIWI MACT rules also include new source performance standards that must be met by newly constructed HMIWI. As noted above, the number of HMIWI in operation has declined substantially in the past decade;

however, some new HMIWI, including both small- and medium-sized captive HMIWI and large commercial HMIWI, have been brought online. Thus, EPA analyzed the potential impacts of the NSPS on new HMIWI.

EPA's estimated the costs that would be incurred by new large, medium, and small HMIWI are shown in Table 4-6. The estimated throughput for the model plants varies from 101 tons per year for the small model plant to 10,720 tons per year for the large model plant. Estimated costs of compliance with the MACT standards for new HMIWI are uniformly higher than the cost of installing an autoclave and disposing of the waste at an off-site landfill.

To analyze the economic impacts on new HMIWI sources, EPA first characterized the model plants' operating costs based on similar recently-constructed existing plants. The model plant baseline operating costs are also shown in Table 4-6. EPA estimated per-ton costs of both autoclave/landfill treatment/disposal and HMIWI treatment including costs of complying with

Table 4-6. Estimated MACT Floor Costs for New HMIWI Sources

New HMIWI Model Plant	Estimated Throughput (tons/year)	Estimated Autoclave/ Landfill Costs ($$10^3$ 2007)	Estimated Baseline HMIWI Operating Costs ($$10^3$ 2007)	Estimated MACT Floor TAC ($$10^3$ 2007)	Total Estimated HMIWI Cost ($$10^3$ 2007)
New large	10,720	730	1,025	1,083	2,108
New medium	603	50	337	116	453
New small	101	15	117	118	235

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for New HMIWI.; Holloway, T. June 19, 2009. Baseline Operating Costs for New HMIWI

the revised HMIWI MACT. These are shown in Table 4-7. Using Equation 4.2, above and assuming a price-elasticity of −1.2, EPA estimated the price, including markup, that firms would charge if faced with these per-ton costs (also shown in Table 4-7).

Table 4-7. Per-Ton Costs and Market Prices for New HMIWI

New HMIWI Model Plant	Estimated Throughput (tons/year)	Estimated Autoclave/ Landfill Costs ($/ton)	Estimated Baseline HMIWI Operating Costs ($/ton)	Estimated MACT Floor TAC ($/ton)	Total Estimated HMIWI Cost ($/ton)	Estimated Market Price ($/ton)
New large	10,720	68	96	101	197	1,180
New medium	603	83	559	192	750	4,503
New small	101	146	1,168	1,171	2,340	14,034

Source: Holloway, T. July 6, 2009. Revised Compliance Costs and Economic Inputs for New HMIWI.

It is clear from the data in Table 4-7 that new HMIWI plants experience economies of scale. That is, larger HMIWI experience lower costs per ton of waste treated than do smaller HMIWI. This trend is true for both operating costs and costs of complying with the revised MACT standards. Assuming a monopolistic market structure and a moderate price elasticity, EPA estimates market prices that are considerably higher than per-ton costs, ranging from $978 per ton for the services of new large HMIWI, to $14,997 per ton for new small HMIWI.

To assess the impacts of the revised MACT standards on investment in new HMIWI, EPA compared the market prices for new HMIWI and with-regulation market prices estimated for existing HMIWI. With-regulation market prices for existing commercial HMIWI are estimated to range from $288 per ton to $5,195 per ton, depending on the region of the country; with-regulation prices for existing HMIWI average $1,106 per ton. Comparing estimated with-regulation prices for new and existing HMIWI, it appears that new large HMIWI and possibly new medium HMIWI could profitably be installed in many areas of the country, if demand were sufficient. New commercial small HMIWI do not appear viable, and new commercial medium HMIWI may not be viable, based on these analyses. However, a hospital, pharmaceutical company, research facility, or university might choose to purchase and install a new small captive HMIWI if specialized treatment needs required it. It should also be noted that autoclave treatment, followed by landfilling off-site, is less costly than HMIWI operation, especially for new medium and small HMIWI. The relatively lower costs of autoclave treatment and landfill disposal will continue to encourage generators to use good waste segregation practices to minimize the volume of waste sent to a HMIWI for incineration.

SECTION 5
CONCLUSIONS

This document has analyzed the economic impacts of the revised HMIWI MACT standards, through a careful characterization of affected facilities, firms, and markets, and an assessment of how these entities and institutions may be affected by the costs required to comply with the rule.

Currently, there are 57 existing HMIWI units at 51 facilities. They may be divided into two broad categories: captive HMIWI, which are co-owned and co-located with generating facilities and provide on-site incineration services for waste generated by the hospital, research facility, university, or pharmaceutical operations, and commercial HMIWI, which provide commercial incineration services for waste generated off-site by firms unrelated to the firm that owns the HMIWI. EPA analyzed the impacts on captive HMIWI and commercial HMIWI using different methods.

Impacts on captive HMIWI are estimated by comparing the cost of complying with the revised HMIWI MACT standards to the HMIWI owners' sales or revenues. This approach assumes that the owner will absorb the costs of complying and will not change their operations or the prices they charge for their goods or services to pass along a share of the costs of compliance. The cost-to-sales ratios for firms owning captive HMIWI are low, reflecting the relatively small share of overall costs that are associated with hospital/medical/infectious waste management at these firms. Of the 35 firms owning captive HMIWI, 22 have costs of compliance that are less than 0.1% of firm sales. Of the 13 with costs exceeding 0.1% of sales, the largest cost to sales ratio is at a captive hospital HMIWI, and is equal to 0.995%.. At the same time, EPA acknowledges that the firms may in fact be able to pass a portion of compliance costs along to their customers. They may also have ways to reduce the cost of complying with the revised HMIWI MACT standards, such as improving waste segregation and sending a higher share of the waste they generate to an on-site autoclave for treatment, followed by disposal at an off-site landfill. In addition, some captive HMIWI may choose to shut down their HMIWI rather than comply with the revised MACT standards; if so, they would divert the hospital/medical/infectious waste that must be incinerated to a commercial HMIWI (thereby increasing the demand for commercial HMIWI services).

Impacts on commercial HMIWI are analyzed using the simplifying assumption that they operate as regional monopolists (in general, only one HMIWI is considered as a treatment option by generators located nearby). This market structure was chosen because the 10 commercial

HMIWI are widely distributed around the county and are owned by only five firms/entities. A regional monopoly means that the HMIWI have some market power and are able to charge a price that covers the costs of complying with the MACT standards, plus a mark-up. The demand for the services of most commercial HMIWI is characterized assuming a moderate price-elasticity of demand (−1.2), meaning that for each 1% increase in price, quantity treated falls by 1.2%. In response to comments indicating a more elastic demand relationship for their services, we assume Curtis Bay Energy faces a demand curve with price-elasticity of −10. With-regulation prices for HMIWI services vary considerably, as a result of varying baseline and compliance costs incurred by the HMIWI. In each market, per-ton prices increase by more than the per-ton costs of compliance, so that per-ton profits increase. Because quantity treated falls, however, aggregate costs, revenues, and profits are projected to decline. However, commercial HMIWI may experience increased demand for their services if some captive HMIWI choose to shut down their HMIWI and divert a share of the waste they generate to commercial treatment. If so, this increase in demand could at least partially offset the reduction in quantity treated that is projected by the model. EPA also examined the potential impacts on owners of commercial HMIWI, by comparing estimated MACT floor costs to revenue of the firm or government owning the HMIWI. These cost-to-revenue ratios range from less than 0.1% for Healthcare Environmental Services to 45.1% for Curtis Bay Energy. Although EPA's analysis indicates that commercial HMIWI will be able to increase the price of their services sufficiently to cover their costs of compliance, EPA does not have sufficient information about the financial status of Curtis Bay Energy to be certain that they would not encounter difficulties in complying with the rule. Comparing the most recent publicly available sales data for Curtis Bay Energy with estimated baseline operating and emissions control costs, the analysis estimates that CBE's profits are marginal at baseline, consistent with the profitability discussion CBE provided in their comments; compliance with the rule is estimated by the market analysis to further reduce their profitability.

EPA's analysis of impacts of the revised HMIWI MACT standards on new HMIWI sources compares the with-regulation estimated prices that would be charged by new large, medium, and small HMIWI to the range of with-regulation prices estimated to be charged by existing commercial HMIWI in various regional markets. This comparison indicates that new large and medium commercial HMIWI may be viable, but new small commercial HMIWI probably would not be viable. On the other hand, generators of hospital/medical/infectious waste could have overarching business reasons to purchase and install a new small HMIWI. Comparison of autoclave treatment coupled with off-site landfill disposal shows that, for new facilities as for existing ones, autoclave/landfill treatment and disposal is generally less costly than incineration. Thus, the motivation to improve waste segregation to minimize the waste that must be incinerated is likely to continue, although HMIWI treatment of some wastes will continue to be required by regulation.

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